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# Unifying our efforts to dignify medical training and work

**Dr. José María Varaona**

*President of the Asociación Argentina de Ortopedia y Traumatología*



Dear reader,

The Asociación Argentina de Ortopedia y Traumatología (*Argentine Association of Orthopedics and Traumatology* - AAOT) has an academic tradition of more than 86 years in the training of professionals in this specialty in Argentina. However, we are currently facing important changes, especially in terms of dignifying medical work, restoring adequate financial remuneration, and protecting our profession in the face of the increasing prosecution of medicine. For this reason, the Board of Directors that I chair will work together with the Regional Associations, SUTYO, FAAOTEP and the *Agremiación Argentina de Ortopedia y Traumatología (Argentine Orthopedics and Traumatology Trade Association)* to improve agreements with health funders, defend professional interests, and mediate in conflicts between associates.

However, it is important to remember that, to achieve these objectives, the participation of all traumatologists in the country is essential. Therefore, it is essential to identify the problems we face in our daily practice and take steps to solve them. One of the areas where we can make a difference is in the training of new doctors. In 2022, approximately 346 residency positions in Orthopedics and Traumatology were offered in 140 health centers in the country. According to data from the AAOT Residency Committee, Argentina has a higher number of trauma specialists per inhabitant than the average of other countries. In fact, we form one resident for every 131,000 inhabitants per year, while in Uruguay, one is formed for every 315,000 inhabitants; in Colombia, every 678,000; in Ecuador, every 840,000; in France, every 500,000; and, in the United States, every 379,000.

We need to overcome the old misconception that having a large number of residents reduces employment costs and sometimes exposes recent graduates to excessive workloads, administrative work or paramedical activities, leading to a market oversupply of professionals who renounce their labor rights in order to work. In addition, this excess of new professionals leads to a reduction in the practical experience of these doctors, associated with the deficient theoretical training that is observed in many training centers, as reflected in the increasing failure rate in certification exams.

For this reason, we must reflect on whether the current number of vacancies and the quality of the training system are adequate. For this, we will carry out awareness meetings with the heads of services and directors of the country's training programs and we will try to expose this situation to the national and provincial Ministries of Health, Universities, and Medical Colleges to take measures that improve the quality of our professionals.

As of 2022, all specialists certified by the AAOT must be recertified every 5 years to guarantee their constant updating. The AAOT and its committees intend to make available to its members all the educational tools at our disposal through a new Virtual Campus, where members will be able to freely access practical instruction courses, surgical techniques, and contents of courses taught in previous years, as well as orthopedic and trauma guides

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complementary to the Triennial Course and other useful educational content for their training. A basic course for first-year residents will also be created in order to accompany professionals throughout their residency. In addition, courses in critical reading and preparation of scientific papers will continue to be offered to stimulate the presentation of scientific papers and improve the quality of our journal.

To optimize the practical training of professionals, various surgical skill courses and anatomical workshops will be offered at the AAOT Skills Center and in different parts of Argentina. Also, training opportunities will be provided to colleagues from all over the country through transfers and training scholarships in national centers. These and other measures will be implemented soon.

Finally, we will seek to obtain new funds and resources, and optimize those already available through austere and sensible management.

I wish all of you the very best in this new year.

Sincerely,

# Modified Mitchell's Osteotomy for the Treatment of Hallux Valgus Rigidus. Description of the Surgical Technique and Medium-term Functional Evaluation

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## ABSTRACT

**Objective:** To describe the modified Mitchell's surgical technique for the treatment of grade II hallux valgus rigidus, and to evaluate medium-term outcomes. **Materials and Methods:** Prospective observational study. Between August 2015 and January 2019, 21 patients (23 feet) with grade II hallux valgus rigidus were treated. All underwent a modified Mitchell's osteotomy. **Results:** The results are reported based on age, gender, postoperative follow-up, AOFAS score, affected foot, loss of reduction, metatarsal head collapse, residual pain, and whether the patient needed insoles to be discharged. The AOFAS score at 18 months was 94.78. On average, the patients returned to work after 16.6 days and to their usual activities after 3.43 months. **Conclusion:** We present a surgical technique that combines the benefits of the Chevron and Mitchell osteotomy, with excellent functional clinical outcomes.

**Keywords:** hallux valgus rigidus, Mitchell's osteotomy

**Level of Evidence:** IV

## Tratamiento del hallux valgus rigidus con osteotomía tipo Mitchell modificada. Descripción de la técnica quirúrgica y evaluación funcional a mediano plazo

## RESUMEN

**Objetivo:** Describir la técnica quirúrgica de Mitchell modificada para el tratamiento del hallux valgus rigidus grado 2, y evaluar los resultados a mediano plazo. **Materiales y Métodos:** Estudio prospectivo observacional. Entre agosto de 2015 y enero de 2019, 21 pacientes (23 pies) con hallux valgus rigidus grado 2 fueron sometidos a una osteotomía tipo Mitchell modificada. **Resultados:** Se comunican los resultados sobre la base a la edad, el sexo, el seguimiento posoperatorio, el puntaje de la AOFAS, el pie afectado, la pérdida de reducción, el colapso de la cabeza del metatarsiano, el dolor residual y la necesidad de plantillado para el alta. El puntaje de la AOFAS a los 18 meses fue de 94,78. Los pacientes retornaron a su actividad laboral fue, en promedio, a los 16.6 días y a sus actividades previas, a los 3,43 meses. **Conclusión:** Presentamos una técnica quirúrgica que combina los beneficios de la osteotomía de Chevron y la de Mitchell, con excelentes resultados clínicos funcionales.

**Palabras clave:** Hallux valgus rigidus, osteotomía de Mitchell.

**Nivel de Evidencia:** IV

## INTRODUCTION

The term hallux rigidus refers to degenerative arthritis of the metatarsophalangeal joint. Davies-Colley provided the first description of this condition in 1887 and Cotterill coined the term hallux rigidus. After hallux valgus, it is the most common condition of the big toe.<sup>1</sup>

Hallux valgus rigidus is a common degenerative deformity characterized by subluxation of the first metatarsophalangeal joint, with lateral deviation of the hallux and medial deviation of the first metatarsal (M1). The etiology remains unknown, although there are several theories about it. It predominates in the female sex, with a ratio of 3 to 1.<sup>2-4</sup>

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Many surgical techniques have been published to correct hallux valgus and hallux rigidus deformity, but not for hallux valgus rigidus.

The M1 distal osteotomy can be used to correct varying degrees of hallux deviations.

The most widely used surgical procedures for the correction of hallux rigidus include dorsal cheilectomy, Green-Watermann osteotomy, and arthrodesis for the most severe cases.<sup>1</sup>

In 1958, Mitchell<sup>5</sup> described a double step-cut osteotomy through the neck of M1 causing its lateral displacement and shortening. Originally, the osteotomy was fixated with a circumferential suture placed through two parallel perforations and tied dorsally. Indications for this procedure were: young patients with severe hallux valgus, moderate or severe pain, joint deformity and instability, inability to wear appropriate footwear, and conservative treatment failure.<sup>6</sup> The main complication described as a result of this osteotomy is the recurrence of hallux valgus with pain in the medial eminence.<sup>7</sup>

The hypothesis put forward is that the surgical technique described in this study achieves excellent clinical-functional outcomes in the medium term and is reproducible. Therefore, the objective of this study was to describe the surgical technique and evaluate the results in the medium term.

## MATERIALS AND METHODS

### Population sample

An observational prospective study was carried out. Between August 2015 and January 2019, 21 patients (23 feet) were treated with hallux valgus associated with grade 2 hallux rigidus, according to the Coughlin and Shurnas classification.<sup>8</sup> This classification divides them into five grades (from 0 to 4), considering the range of motion of the hallux metatarsophalangeal joint, radiographic changes, and clinical manifestations (Table 1). Stage 2 of the classification corresponds to a 10-30° dorsiflexion or a 50-75% loss of range of motion compared to that on the unaffected side. Radiographs show dorsal, lateral, and medial osteophytes, a flattened head, less than 25% involvement of the dorsal joint space, mild to moderate joint space narrowing and sclerosis, without sesamoid involvement. Regarding the clinical signs, the patient feels moderate to intense pain and there is stiffness that can be constant.

**Table 1.** Coughlin and Shurnas classification

Grade	Arc of motion	Radiograph	Clinical signs
0	40-60° dorsiflexion or 10-20% loss compared to normal side	Normal or minimal	No subjective pain, just stiffness; loss of passive movement on examination
1	Dorsiflexion 30-40° or loss 20-25%	Dorsal osteophyte. Minimal joint impingement. Minimal periarticular sclerosis. Minimal head flattening	Occasional mild or subjective pain and stiffness; pain in the extremities of dorsiflexion or plantarflexion on examination
2	Dorsiflexion of 10-30° or loss of 50-75%	Dorsal, lateral and medial osteophytes. Flattened head. Less than 25% involvement of the dorsal region of the joint space, mild to moderate joint space narrowing and sclerosis, sesamoids unaffected	Subjective moderate to severe pain and stiffness that may be constant; pain on examination just before maximal dorsiflexion or plantarflexion
3	Dorsiflexion of 10° or less, or marked loss of plantarflexion (10° or less)	Like grade 2, but with substantial narrowing; periarticular cystic changes; less than 25% of the dorsal articular region may be involved; enlarged, cystic, or irregular sesamoids	Almost constant subjective pain, throughout the entire arc of motion
4	Stiff joint	Grade 3 plus free bodies and osteochondral defects.	Almost constant/constant pain. Pain throughout the range of motion

Twenty-one patients (23 feet) were evaluated and monitored. All were operated on by the same leg, ankle, and foot specialist surgeon, using a modified Mitchell osteotomy.

The method was selected after a radiographic evaluation and analysis.

Anteroposterior, latero-lateral weight-bearing, and oblique foot radiographs were taken from all patients before surgery to plan it (Figure 1), postoperatively (Figure 2), and 18 months after the intervention (Figure 3) to establish the intermetatarsal angle (IM), hallux valgus angle (HV), distal metatarsal articular angle (DMAA), metatarsophalangeal joint congruency, interphalangeal angle, M1 height, degree of deformity, degree of injury, hallux joint range of motion, and the presence of pain.

The inclusion criteria were: 1) grade 2 hallux rigidus, 2) IM angle  $\geq 7^\circ$  and  $\leq 16^\circ$ , 3) HV angle  $\geq 17^\circ$  and  $\leq 45^\circ$ , 4) DMAA angle  $\geq 6^\circ$  and  $\leq 9^\circ$ , 5) minimum follow-up of 12 months and 6) surgery with the modified Mitchell technique.

The exclusion criteria were: 1) immature skeleton, 2) lack of follow-up, and 3) history of M1 fracture.



**Figure 1.** A-C. Preoperative anteroposterior, oblique, and lateral foot radiographs. D and E. Anteroposterior and oblique images of the foot before surgery.



**Figure 2.** Postoperative anteroposterior, oblique, and lateral foot radiographs.



**Figure 3.** A-C. Anteroposterior, oblique, and lateral foot radiographs 18 months after surgery. **D and E.** Anteroposterior and oblique images of the foot at discharge.

### Surgical technique

The patients were placed in the supine position after spinal anesthesia. A tourniquet was placed on the thigh. A classic 3 to 5 cm medial hallux approach was performed, the capsule was incised in Y to then access the M1, which underwent a dorsal cheilectomy and a bunionectomy with an oscillating saw. The center of rotation of M1 was marked, which is used to practice the cuts. The first was made from the point at the center of rotation of the head of M1 in the plantar direction at 45° proximally. The following cuts were made at the junction of the head and neck of the M1, perpendicular to it, from side to side. The next cut was made 1-3 mm distal to it, leaving a lateral step no greater than 25% of the total width of the metatarsal. The resulting bone layer was used as an additive graft in the plantar cut. The osteotomy is intrinsically stable. It was also fixated with a 3 mm double-thread screw (Figure 4). An image intensifier was used to confirm the correct position of the osteosynthesis.



**Figure 4.** Illustrative model of the first metatarsal. **A.** Cut marks, lateral view. **B.** Cut marks, anteroposterior view. **C.** Cut marks, oblique view. **D.** Osteotomy performed, oblique view. **E.** Screw stabilized osteotomy, anteroposterior view.

A Moberg phalangeal osteotomy was also added. It was performed percutaneously, using a medial approach, a dorsal osteotomy of the proximal metaphysis of the first phalanx of the hallux, with resection of a dorsal wedge at that level.

All patients were treated on an outpatient basis and were allowed immediate weight-bearing with a postoperative sandal. Physical therapy was indicated from the third day after surgery onwards.

Oblique anteroposterior and lateral foot radiographs were taken in the immediate postoperative period to assess for possible loss of reduction. The definitive radiographic outcome was considered 18 months or more after surgery.

For the evaluation, the forefoot scale of the American Orthopaedic Foot and Ankle Society (AOFAS) was used before the intervention and 18 months after surgery. This scale assigns 50 points to function, 40 points to pain, and 10 points to alignment. A perfect score of 100 indicates that the patient is pain-free, has full range of motion in the hallux and forefoot, no instability, good alignment, and the ability to walk more than 6 blocks (600 meters) on any surface, without a limp or limitations in daily or recreational activities or need for technical aids for walking.

The following variables were evaluated: age, sex, postoperative follow-up, AOFAS score (pre- and postoperative), affected foot, hallux metatarsophalangeal joint range of motion (pre- and postoperative), loss of reduction, metatarsal head collapse, residual pain, need for insoles for discharge, return to work and sports activity.

### Statistical Analysis

Categorical variables are expressed in number and percentage. The interval variables are described with mean and median, according to their distribution and their measures of dispersion (standard deviation) and interquartile interval 25-75. A comparison of continuous variables was performed using the Student's t-test for related samples. A p-value <0.05 was considered statistically significant. For the analysis, the SPSS Statics 25 program was used.

## RESULTS

Twenty-one patients (23 feet) were included, 19 women and 4 men, with a mean age of 56.9 years (range 23-81) diagnosed with hallux valgus rigidus. The initial characteristics are shown in [Table 2](#) and the group angle changes in [Tables 3 and 4](#).

Hallux metatarsophalangeal range of motion was 16.95° (range 10-30) before surgery and 34.5° (range 25°-45°) 18 months postoperatively.

The AOFAS score for the foot was 43.17 (range 39-57) before surgery and 94.78 (range 80-100) at 18 months. The postoperative visual analog scale score was 9.3 (range 8-10).

The pain disappeared in all patients, they were evaluated every 7 days until completing 30 days after surgery, then every two months, until 12 months after surgery, and a final control at 18 months.

The HV angles were 30.34° (range 17°-45°) before the intervention; 1.60° (range 0°-9°) in the postoperative period and 3.17° (range 2°-9°) at the time of discharge. The preoperative IM angle was 13.43° (range 7°-16°) and 6.56° (range 3°-12°) postoperatively and 6.56° (range 3°-12°) at discharge. Preoperative, postoperative, and discharge DMAA angles were 7.78° (range 6°-9°), 7.17° (range 6°-9°), and 7.17° (range 6°-9°), respectively.

In addition, a Moberg osteotomy was performed in 13 patients who had limited metatarsophalangeal range of motion during surgery, after the technique described in this study.

The patients resumed their work activity after 16.69 days on average (range 5-60). The return to normal activities occurred, on average, 3.43 months after surgery (range 3-4).

After the osteotomy was consolidated, a lateral displacement of the M1 head was observed in all cases, without collapse or loss of reduction at discharge.

The average surgical time was 25 minutes (range 20-35). No patient required insoles.

Regarding complications, one patient suffered a postoperative infection that required cleaning and intravenous antibiotics without the need to remove the screw.

In no case was a second intervention or subsequent arthrodesis necessary.

**Table 2.** Sample Description

Variable		Result
Sex, n (%)	Female	19 (82.6)
	Male	4 (17.4)
Age	Mean (SD)	57 (15)
	Median (IQR 25-75)	56 (49-71)
Affected side, n (%)	Right	13 (56.5)
	Left	10 (43.5)
Previous surgery, n (%)	No	22 (95.7)
	Yes	1 (4.3)
Mitchell, n (%)	Yes	23 (100)
	No	0 (0)
Moberg n (%)	No	10 (43.5)
	Yes	13 (56.5)
Pre-surgical IM angle	Mean (SD)	13 (3)
	Median (IQR 25-75)	14 (12-15)
Pre-surgical HV angle	Mean (SD)	30 (7)
	Median (IQR 25-75)	30 (25-35)
Pre-surgical DMAA angle	Mean (SD)	8 (1)
	Median (IQR 25-75)	8 (7-9)
Post-surgical IM angle	Mean (SD)	7 (2)
	Median (IQR 25-75)	7 (6-7)
Post-surgical HV angle	Mean (SD)	2 (2)
	Median (IQR 25-75)	0 (0-3)
Post-surgical DMAA angle	Mean (SD)	7 (1)
	Median (IQR 25-75)	7 (7-8)
IM angle at discharge	Mean (SD)	7 (2)
	Median (IQR 25-75)	7 (6-7)
HV angle at discharge	Mean (SD)	3 (2)
	Median (IQR 25-75)	3 (2-5)
DMAA angle at discharge	Mean (SD)	7 (1)
	Median (IQR 25-75)	7 (7-8)
Posterior arthrodesis, n (%)	Yes	0
	No	23 (100)
Return to previous activities (months)	Mean (SD)	3 (1)
	Median (IQR 25-75)	3 (3-4)
Return to work (days)	Mean (SD)	17 (14)
	Median (IQR 25-75)	12 (7-21)
Visual Analog Scale	Mean (SD)	9 (1)
	Median (IQR 25-75)	9 (9-10)
Preoperative AOFAS	Mean (SD)	43 (6)
	Median (IQR 25-75)	43 (39-57)
Postoperative AOFAS	Mean (SD)	95 (6)
	Median (IQR 25-75)	100 (90-100)

Abbreviations: IM = intermetatarsal; HV = hallux valgus; DMAA = distal metatarsal articular angle; AOFAS = American Orthopedic Foot & Ankle Society; SD = Standard deviation; IQR 25-75 = interquartile range 25-75.

**Table 3.** Radiographic results in the immediate postoperative period

Angle	Preoperative Mean (SD)	Postoperative Mean (SD)	p <sup>(*)</sup>
IM	13 (3)	7 (2)	0.000
HV	30 (7)	2 (2)	0.000
DMAA	8 (1)	7 (1)	0.002

\*T-test p-value for related samples. Abbreviations: IM = intermetatarsal; HV = hallux valgus; DMAA = distal metatarsal articular angle; SD = Standard deviation

**Table 4.** Radiographic results at discharge

Angle	Preoperative Mean (SD)	Postoperative Mean (SD)	p*
IM	13 (3)	7 (2)	0.000
HV	30 (7)	3 (2)	0.000
DMAA	8 (1)	7 (1)	0.002

\*T-test p-value for related samples. Abbreviations: IM = intermetatarsal; HV = hallux valgus; DMAA = distal metatarsal articular angle; SD = Standard deviation

## DISCUSSION

There are numerous surgical techniques for the treatment of hallux rigidus: dorsal cheilectomies, proximal phalanx osteotomies (described by Bonney and Macnab, and later popularized by Moberg), metatarsal osteotomies (such as the one described by Green-Watermann), Keller resection arthroplasty, interpositional arthroplasty, partial or total prosthetic arthroplasty and, finally, arthrodesis.<sup>1,9</sup>

Although there is no consensus on the ideal treatment for this condition, most authors recommend surgery for the treatment of moderate and severe hallux rigidus.

Many of the distal metatarsal osteotomies are aimed at correcting the metatarsus primus elevatus, although, in recent studies, it was observed that 94% of patients with hallux rigidus did not have such deformity.<sup>10</sup> The shortening obtained with the proposed technique is limited; this osteotomy offers the possibility of lowering the head of M1, shortening or lengthening it depending on how the cut is made.

Baba et al.<sup>11</sup> reported that transfer metatarsalgia occurs with shortenings >8–10 mm. In our series, we did not detect transfer metatarsalgia, we believe it may be due to the fact that it was an osteotomy with limited shortening of 1 to 3 mm, as needed.

The thickness of the extracted bone fragment is important. One of the disadvantages of the classical Mitchell method is the shortening of the first ray causing transfer metatarsalgia.<sup>12</sup> In our technique, the bone fragment extracted did not exceed 2 mm and we did not observe transfer metatarsalgia in the patients evaluated.

The results of the Moberg osteotomy are equivocal, which has led to insufficient evidence of its results to date.<sup>13</sup> In our study, this procedure was not performed routinely, it was only reserved for cases with a restricted metatarsophalangeal range of motion (<45°).

In Mitchell's original technique, fixation of the osteotomy was accomplished by cerclage wiring. A nonunion rate of 4% to 7% was reported.<sup>14</sup> Currently, there are multiple types of fixation in first-ray distal metatarsal osteotomies: Kirschner pins, bioabsorbable pins, screws, staples, sutures, or wire, as the technique was initially popularized.<sup>15</sup> Mitchell's osteotomy is stable *per se*; however, we believe the use of a fixation method is necessary. In this case, we use a self-compressive double-threaded screw. No undesired displacements or loss of reduction or pseudarthrosis were observed.

Angle corrections (IM and HV) pre- and postoperatively were similar to those reported in the literature. Ayoubi et al.<sup>14</sup> reported postoperative IM and HV angle corrections of 5°–7.8° and 27°, respectively. In our research, they were 7° and 28°, respectively.

The AOFAS score was 94 18 months after surgery, a score similar to or higher than that published by other authors.<sup>14</sup>

Our technique modification includes:

1. A distance between cuts of no more than 2 mm, to avoid shortening.
2. A cut of the plantar branch at 45°.
3. The width of the remaining step is not greater than 25% of the total width of the metatarsal.
4. Fixation with a self-compressive double-threaded screw.
5. Autologous bone graft obtained from the distal metatarsal cut to descend the first metatarsal head.

A complication occurred: one patient required cleaning and antibiotics, without the need to remove the screw. As mentioned before, this osteotomy is stable and maintains reduction by itself; therefore, material removal is not problematic, as it can be with other M1 osteotomies, as long as it is protected from weight-bearing.

This study has several limitations: its non-randomized prospective design, a very wide age range, and a relatively small number of cases. As strengths, the description of a new surgical technique and a long-term follow-up period can be mentioned.

## CONCLUSION

The results of this study demonstrate that the modified Mitchell technique and stabilization of the osteotomy with a screw are effective solutions for the treatment of moderate hallux valgus rigidus. This surgical technique is low-cost, reliable and reproducible.

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Conflict of interest: The author declares no conflicts of interest

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# Evans Osteotomy Without Bone Graft in Stage IIB Adult Flatfoot Deformity

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## ABSTRACT

**Objective:** to evaluate the radiological and functional outcomes one year after surgery in a consecutive series of patients diagnosed with stage IIB adult-acquired flatfoot deformity who underwent Evans osteotomy without the use of bone graft. **Materials and Methods:** Two groups of patients were retrospectively evaluated: group 1 (spacer plate, n=12) and group 2 (PEEK cage, n=14). The mean age was 47 years (SD 18) in group 1 and 54 years (SD 12) in group 2. **Results:** 26 patients (28 feet) were evaluated; 14 (84%) of the patients were women. Radiographic measurements—calcaneal pitch angle, (lateral) talocalcaneal angle, (AP) talocalcaneal angle, talonavicular coverage angle, medial column height, lateral column length—yielded statistically significant differences between preoperative measurements and those taken one year after surgery. The mean score on the AOFAS scale one year after surgery was 96 (SD 4.70) in group 1 and 95 (SD 4.98) in group 2. Regarding the visual analog scale, it was 1.2 (SD 0.42) in group 1 and 1.16 (SD 0.46) in group 2. **Conclusions:** According to the results obtained, we conclude that Evans osteotomy without the use of bone graft manages to preserve the corrections obtained in the medium term, using either spacer plates or PEEK cages.

**Keywords:** flatfoot deformity; Evans osteotomy; lateral column lengthening

**Level of Evidence:** III

## Osteotomía de Evans sin injerto óseo en el pie plano estadio IIB del adulto

## RESUMEN

**Objetivo:** Evaluar los resultados radiográficos y funcionales al año de la cirugía, en una serie consecutiva de pacientes con diagnóstico de pie plano valgo estadio IIB, sometidos a una osteotomía de Evans sin injerto óseo. **Materiales y Métodos:** Se evaluó, en forma retrospectiva, a dos grupos de pacientes: grupo 1 (placa con espaciador, n = 12) y grupo 2 (celdas de PEEK, n = 14). La edad promedio era de 47 años (DE 18) en el grupo 1 y de 54 años (DE 12) en el grupo 2. **Resultados:** Se evaluó a 26 pacientes (28 pies operados); 20 (77%) eran mujeres. Las mediciones radiográficas: ángulo de inclinación del calcáneo, ángulo astrágalo-calcáneo (perfil), ángulo astrágalo-calcáneo (frente), cobertura astragalonavicular, altura de la columna medial, longitud de la columna externa, arrojaron diferencias estadísticamente significativas entre las determinaciones preoperatorias y al año de la cirugía. El puntaje promedio de la escala de la AOFAS al año fue de 96 (DE 4,70) en el grupo 1 y de 95 (DE 4,98) en el grupo 2. El puntaje en la escala analógica para dolor fue de 1,2 (DE 0,42) en el grupo 1 y 1,16 (DE 0,46) en el grupo 2. **Conclusiones:** De acuerdo con los resultados obtenidos, concluimos en que la osteotomía de Evans sin el uso de injerto óseo logra preservar las correcciones obtenidas en el mediano plazo utilizando placas con espaciador o celdas de PEEK.

**Palabras clave:** Pie plano; osteotomía de Evans; elongación; columna externa.

**Nivel de Evidencia:** III

## INTRODUCTION

Adult pes planovalgus (PPV) is a relatively common condition in the foot and ankle specialty; it affects 20-30% of the general population, and it is more frequent in females around the fifth or sixth decade of life.<sup>1</sup> Although the etiology can be attributed to systemic inflammatory, developmental, or neuromuscular diseases, and even trauma, posterior tibial tendon dysfunction remains the most common cause.

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Clinically, stage IIB is characterized by loss of the medial longitudinal arch, hindfoot valgus, forefoot abduction, too many toes sign, and inability to invert the hindfoot when raising the heels while standing (heel rise test).<sup>2-4</sup>

In 1989, Johnson and Strom<sup>5</sup> classified posterior tibial tendon dysfunction into three stages; later this classification was modified by Bluman et al.<sup>6</sup> who added stage IV. One of the surgical procedures proposed for the treatment of stage IIB is the lengthening of the lateral column by means of the Evans osteotomy, indicated only in patients with a flexible deformity.

The lateral column is made up of the fourth and fifth tarsometatarsal joints, the cuboid, the calcaneocuboid joint, and the calcaneus.

The Evans osteotomy is performed 1.5–2 cm proximal to the articular surface of the calcaneocuboid joint,<sup>7</sup> and the diastasis can be maintained by placing a tricortical bone graft,<sup>8</sup> plates with a spacer plus bone graft, or other less widespread alternatives, such as PEEK (polyetheretherketone) cages originally designed as an interbody spacer for spinal arthrodesis surgeries (Figures 1-3).<sup>9-12</sup>



**Figure 1.** Evans osteotomy.



Figure 2. Plate with a spacer.

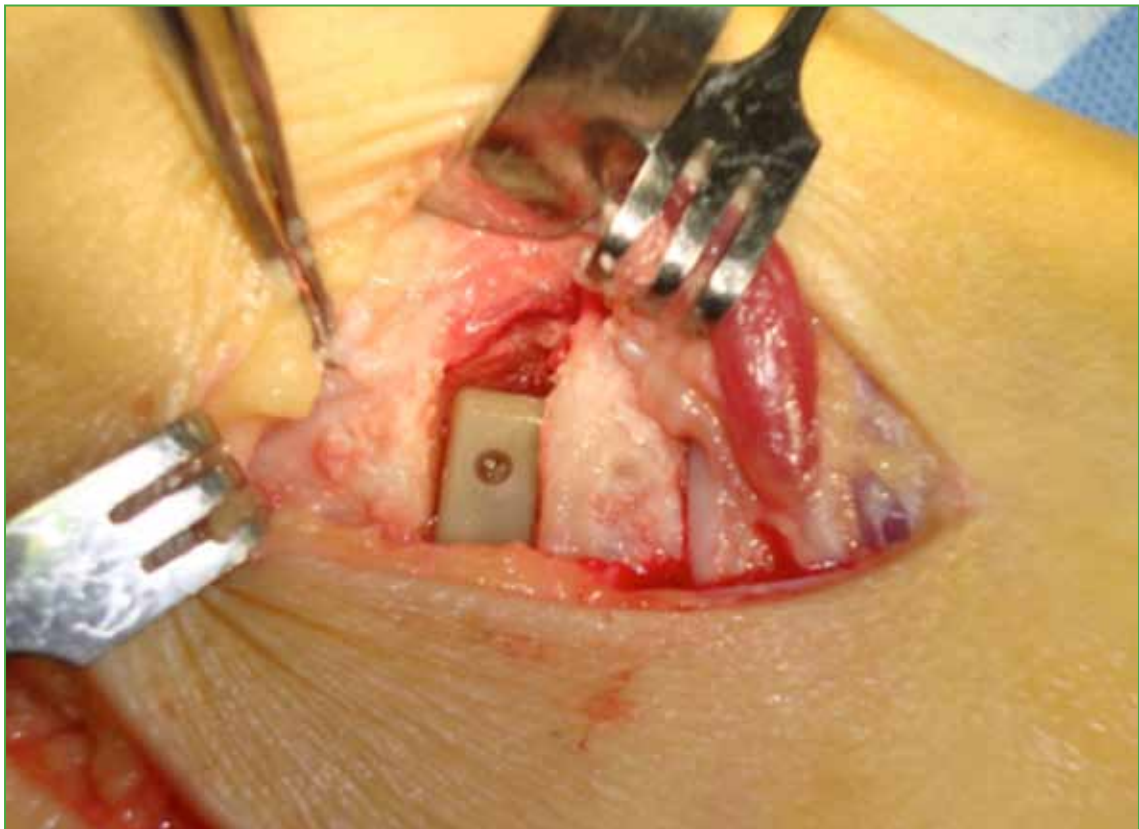


Figure 3. PEEK cage.

This procedure generates a three-dimensional correction, characterized simultaneously by forefoot adduction at the talonavicular joint, midfoot plantarflexion, and hindfoot valgus correction. At present, there are controversies about which is the most adequate method to maintain the distraction of said osteotomy.

One of the main factors for the failure of this osteotomy in the long term is the delay in consolidation or pseudarthrosis, which would result in a loss of the correction obtained.<sup>13</sup>

The objective of this study was to evaluate the radiographic and functional outcomes one year after surgery, in a consecutive series of patients with stage IIB PPV, who underwent an Evans osteotomy without bone graft.

## MATERIALS AND METHODS

A retrospective study was carried out on a consecutive series of patients with flexible flatfoot with hindfoot valgus and forefoot abduction (stage IIB PPV), who had undergone lateral column lengthening (Evans osteotomy) without the use of a bone graft, between March 2010 and March 2014, in the Foot and Ankle Medicine and Surgery Sector of the Orthopedics and Traumatology Service of our institution. Patients with revision surgery, systemic diseases, neurological sequelae, or follow-up <1 year were excluded.

The information of the patients was collected from the electronic health records. This study was evaluated and approved by the Ethics Committee of the institution.

### Clinical-radiographic study

All patients had preoperative and postoperative radiographic measurements three months and one year after surgery. Functional assessment was performed using the AOFAS scale (American Orthopedic Foot and Ankle Society) and the visual analog scale for pain before surgery and one year after it. The clinical-radiographic evaluations were carried out by two specialists in foot and ankle surgery.

The following measurements were taken:

### Lateral radiographs

- *Calcaneal inclination*: it was measured by drawing a line tangent to the lower edge of the calcaneus and another line from the lower edge of the medial sesamoid to the inferior process of the calcaneus. A value from 18° to 20° was considered normal.

- *Medial column height*: it was measured as the distance between the line of the base of the first metatarsal to the line that passes through the inferior border of the medial sesamoid. Values of  $20 \pm 3$  mm were considered normal.

- *Talus-first metatarsal angle*: a line connecting the longitudinal axis of the talus with the axis of the first metatarsal (the longitudinal axis of the talus is measured by placing a midpoint between the superior and inferior face in the center of the articular surface and a midpoint in the neck of the talus). The normal value is  $0 \pm 4^\circ$ .

### Anteroposterior radiographs

- *Talus-first metatarsal angle*: the angle formed by a line drawn by the axis of the first metatarsal and another that passes through the axis of the talus. The normal value is  $0 \pm 5^\circ$ .

- *Talonavicular coverage*: it is measured as the angle formed by a line drawn perpendicular to the articular surface of the talus and a second line perpendicular to the articular surface of the navicular. The normal value is from 0 to 10°.

- *Length of the lateral column*: a line that goes from the posterior process of the calcaneus to the metatarsophalangeal joint of the fifth toe. The normal value is  $160 \pm 5$  mm in length.

The patients were analyzed in two groups according to the method used for the lengthening of the lateral column: group 1, with a locking plate with a spacer, and group 2, with PEEK cages.

### Statistical Analysis

Continuous variables are expressed as median with their respective interquartile range 25-75 and categorical variables, as relative or absolute frequencies. Comparisons between radiographic measurements were made using Student's t-test for paired samples. Preoperative measurements were compared with those obtained at 12 months, and measurements at three months with those at 12 months. A p-value <0.05 was considered statistically significant.

## RESULTS

Between March 2010 and March 2014, 77 patients with stage II PPV underwent surgery. In the study, 26 patients were included, 20 (77%) were women and two underwent surgery on both feet (28 feet). The mean age was 47 years (standard deviation [SD] 18) in group 1 and 54 years (SD 12) in group 2.

In 14 feet, an Evans osteotomy was performed with a locking plate with a spacer (group 1), while in the remaining 14 feet, PEEK cages were used (group 2). The surgeries were carried out by the same team of surgeons specializing in foot and ankle pathologies.

The average surgical time was 117 min (SD 4) in group 1 and 104 min (SD 5) in group 2 ( $p = 0.05$ ).

When analyzing the radiographic variables in group 1 (plates with a spacer) and group 2 (PEEK cages), statistically significant differences were observed between the preoperative measurements and those taken 12 months after surgery, except for the lateral column length variable. (Tables 1 and 2).

**Table 1.** Radiographic measurements in the preoperative period and 12 months after surgery in group 1 (plates with a spacer) (n = 14 feet)

Measurement*	Preoperative period	12 months after surgery	p
Calcaneal inclination angle	12.70° (10-14)	21.18° (18-27)	<0.05
Talocalcaneal angle (lateral)	16.22° (12-20)	5.9° (0-7)	<0.05
Talocalcaneal angle (AP)	21.86° (19-31)	3.68° (2-9)	<0.05
Talonavicular coverage	23.56° (16-41)	5.6° (2-9)	<0.05
Medial column height	10.75 mm (9-16)	18.51 mm (18-21)	<0.05
Lateral column length	162 mm (157-170)	163 mm (155-167)	<b>0.48</b>

\*The values are expressed as median (interquartile range).

**Table 2.** Radiographic measurements in the preoperative period and 12 months after surgery in group 2 (PEEK cages) (n = 14 feet)

Measurement*	Preoperative period	12 months after surgery	p
Calcaneal inclination angle	12.80° (9-15)	19.32° (15-24)	<0.05
Talocalcaneal angle (lateral)	19.03° (16-23)	5.33° (3-10)	<0.05
Talocalcaneal angle (AP)	22.04° (16-25)	4.15° (3-13)	<0.05
Talonavicular coverage	23.75° (19-44)	7.61° (5-14)	<0.05
Medial column height	13.5 mm (12-15)	21.15 mm (19-26)	<0.05
Lateral column length	168.5 mm (160-173)	169.4 mm (164-171)	0.17

\*The values are expressed as median (interquartile range).

The same measurements were taken three months and 12 months after the operation and no statistically significant differences ( $p>0.05$ ) were found in either of the two groups (Tables 3 and 4).

**Table 3.** Radiographic measurements 3 and 12 months after surgery in group 1 (plates with a spacer) (n = 14 feet)

Measurement*	3 months after surgery	12 months after surgery	p
Calcaneal inclination angle	22.58° (17-26)	21.18° (18-27)	0.71
Talocalcaneal angle (lateral)	2.01° (0-8)	5.9° (0-7)	0.1
Talocalcaneal angle (AP)	3.24° (1-7)	3.68° (1-9)	0.05
Talonavicular coverage	2.9° (2-7)	5.6° (2-9)	0.92
Medial column height	19.90 mm (17-22)	18.51 mm (18-21)	0.88
Lateral column length	163.85 mm (159-168)	163 mm (155-167)	0.39

\*The values are expressed as median (interquartile range).

**Table 4.** Radiographic measurements 3 and 12 months after surgery in group 2 (PEEK cages) (n = 14 feet)

Measurement*	3 months after surgery	12 months after surgery	p
Calcaneal inclination angle	21.16° (18-24)	19.32° (15-24)	0.94
Talocalcaneal angle (lateral)	7.17° (4-11)	5.33° (3-10)	0.94
Talocalcaneal Angle (AP)	4.29° (2-12)	4.15° (3-13)	0.24
Talonavicular coverage	8.27° (4-15)	7.61° (5-14)	0.9
Medial column height	22.95 mm (20-23)	21.15 mm (19-26)	0.89
Lateral column length	167.5 mm (163-175)	169.4 mm (164-171)	0.76

\*The values are expressed as median (interquartile range).

When the radiographic measurements were analyzed according to the type of intervention, similar results were obtained in both groups. In the first instance, an improvement was observed in all postoperative measurements when compared with the preoperative ones, and they maintained stability between 3 and 12 months after surgery. These differences were statistically significant, except for the length of the lateral column.

There were no statistically significant differences in the same comparative measurements of both groups in the third and twelfth postoperative months.

The average score on the AOFAS scale was 48.57 (SD 10.44) before surgery and 96 (SD 4.70) a year later in group 1, while in group 2 it was 49.8 (SD 11.61) and 95 (SD 4.98), respectively.

Regarding the visual analog scale for pain, the results in group 1 were 5.08 (SD 1.13) before surgery and 1.12 (SD 0.42) after one year; and 5.6 (SD 0.42). 0.80) and 1.16 (SD 0.46), respectively, in group 2. In both cases, the measurements were statistically significant.

Complications were divided into early and late. In group 1, one patient had a wound dehiscence and two superficial infections, which were treated with oral antibiotics and healed without complications, and a late complication of asymptomatic calcaneocuboid osteoarthritis that did not require surgical treatment.

In group 2, only late complications occurred: two delayed unions and two losses of osteotomy site reduction. In one patient with delayed union, fusion was achieved, while the other case progressed to nonunion; none had a clinical repercussion that required a new surgery.

## DISCUSSION

Evans osteotomy is one of the tools designed for the treatment of adult PPV. Numerous studies have already shown that lateral column lengthening is a determining factor for the correction of forefoot abduction in adult-acquired flatfoot.<sup>14,15</sup>

The treatment of stage II PPV is the one that generates the most controversy. A 2002 survey of foot and ankle surgeons revealed that 43% would use lateral column lengthening in combination with other procedures to reconstruct a stage IIB flat foot; this highlights the variety in therapeutic approaches.<sup>9</sup>

The results of our study show that the corrections obtained by means of the Evans osteotomy without the use of a bone graft do not change in the short-term follow-up. It is also interesting that all the radiographic variables evaluated before surgery undergo a statistically significant change in the postoperative period, except for the length of the lateral column, which does not show differences when evaluated and compared before surgery and after 3 and 12 months.

This fact coincides with what was published by Kang et al.<sup>16</sup> who found no differences in the length of the lateral column when comparing patients with and without PPV.

Various procedures are used to maintain the space created by the Evans osteotomy. Autologous iliac crest bone grafting is accepted as the best option, although the donor site complication rate is around 20% (pain, neuropraxia, cosmetic problems, hemorrhage, hernias, crest fractures).<sup>17-20</sup> The allograft would eliminate complications at the donor site, but would require a longer consolidation time, the availability of a tissue bank, a higher cost, and the risk of transmission of infectious diseases.<sup>21</sup>

Taking into account the morbidity of the donor site and the problems with allografts, Niño Gómez et al.<sup>8</sup> adopted the use of PEEK cages with autograft for various procedures in foot and ankle surgeries, and achieved bone healing in 21 of 22 patients (mean: 14 weeks).

In our study, consolidation was achieved in three months in 93% of the operated feet; therefore, we can suggest the possibility of dispensing with the use of an autograft or allograft to perform this technique, regardless of the method used to maintain the correction.

Cooper et al.<sup>22</sup> reported that compression forces in the calcaneocuboid joint are multiplied eight times above the normal value when a 10-mm lengthening is performed, which is consistent with what was published by Xia et al.,<sup>23</sup> who suggest a diastasis not greater than 8 mm to avoid the risk of osteoarthritis or calcaneocuboid subluxation.<sup>24</sup> Although correlating the size of the diastasis and its possible complications was not the objective of this study, we detected one case of calcaneocuboid osteoarthritis in group 1 and two subluxations in group 2. Despite this, none of these late complications had clinical relevance, which is consistent with what was published by Ahn et al.,<sup>13</sup> who suggested that it is not necessary to correct subluxations, because they would not generate osteoarthritic changes in the medium term.

Regarding the clinical assessment using the AOFAS scale, a statistically significant improvement was obtained in the values one year after the intervention in both groups. No differences were found when comparing both groups 12 months after surgery.

The limitations of our study are its retrospective and observational design with a short follow-up. The correlation between the size of the diastasis obtained and late complications was not evaluated.

## CONCLUSIONS

The solution to pain caused by PPV remains under development. Based on the results of this study, it can be concluded that Evans osteotomy using lateral column lengthening is a reproducible and reliable method to reconstruct the normal functional stability of the midfoot and hindfoot, and that both locking plates with spacers and PEEK cages manage to preserve the corrections obtained with the Evans osteotomy in the medium term, without the need for a bone graft.

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# Supramalleolar Ankle Block for Foot and Ankle Surgery

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## ABSTRACT

**Background:** We present the description of a supramalleolar ankle block technique and our experience using this technique in foot and ankle surgery. **Materials and Methods:** We performed a retrospective observational study of the past 5 years of patients with foot and ankle pathology that had undergone the supramalleolar ankle block. We excluded patients with a history of previous foot surgery, bilateral surgeries, vascular disease, peripheral neuropathy, diabetes, smoking, or active surgical site infection. The supramalleolar ankle block was guided by anatomic landmarks and we used a solution of lidocaine 2% and bupivacaine 0.5%. We evaluated the duration of the ankle block, the visual analog scale (VAS) for pain 24 hrs after surgery, the time until the first analgesic dose, and the level of patient satisfaction. **Results:** 771 patients were included in this study, all of whom had complete analgesia for at least 12 hrs (mean 18 hrs) after surgery. The mean value on the VAS for pain after 24 hrs was 1.4. On average, the first analgesic dose was administered 16 hrs after surgery. The level of satisfaction about the pain perceived in the first 24 hrs after surgery was: very satisfied (89%), satisfied (10%), and dissatisfied (1%). There were no reports of permanent neurological sequelae, systemic toxicity, or surgical site infections. **Conclusion:** We consider the supramalleolar ankle block a simple, effective, and safe procedure to obtain long-lasting postoperative analgesia.

**Keywords:** peripheral nerve block, foot, and ankle surgery

**Level of Evidence:** IV

## Bloqueo supramaleolar de tobillo para cirugía de pie y tobillo. Estudio retrospectivo de casos de los últimos cinco años

## RESUMEN

**Objetivo:** Describir la técnica de bloqueo supramaleolar de tobillo y nuestra experiencia con este bloqueo en la cirugía de tobillo y pie. **Materiales y Métodos:** Se llevó a cabo un estudio observacional, retrospectivo de los últimos 5 años en pacientes con enfermedad de tobillo y pie, sometidos a un bloqueo supramaleolar de tobillo. Se excluyó a pacientes con cirugía previa, cirugías bilaterales, neuropatía periférica o enfermedad vascular, diabetes, infección activa o tabaquistas. Se realizó el bloqueo supramaleolar de tobillo con lidocaína al 2% y bupivacaína al 0,5%, teniendo en cuenta las referencias anatómicas. Se evaluaron la duración del bloqueo, la escala analógica visual de dolor a las 24 h de la cirugía, el tiempo hasta la toma del primer analgésico y el grado de satisfacción del paciente. **Resultados:** Se incluyó a 771 pacientes operados, todos tuvieron una analgesia completa por, al menos, 12 h (duración promedio 18 h). El puntaje promedio de la escala para dolor a las 24 h fue de 1,4. El tiempo promedio hasta la toma del primer analgésico fue de 16 h. El grado de satisfacción del paciente con el bloqueo y el dolor percibido en las primeras 24 h fue: muy satisfecho (89%), satisfecho (10) y poco satisfecho (1%). No hubo casos de secuela neurológica permanente, toxicidad sistémica ni infección. **Conclusiones:** El bloqueo supramaleolar de tobillo es un método simple, eficaz y seguro que puede realizar el traumatólogo para obtener una analgesia posquirúrgica prolongada.

**Palabras clave:** Bloqueo periférico; cirugía de tobillo y pie.

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## INTRODUCTION

Peripheral block is a modality of anesthesia in which a local anesthetic is injected around a nerve, blocking its sensory and motor function. It allows performing surgeries in high-risk patients by reducing the possible complications of general anesthesia. It is a low-risk procedure, very effective in managing pain after an outpatient procedure and avoids hospitalization or reduces its duration.

Most studies on peripheral blocks for foot and ankle surgery refer to blocks proximal to the popliteal fossa or distal to the ankle, performed by anesthesiologists.<sup>1-3</sup> In 1992, Myerson et al. publish a series of patients who underwent an ankle block for foot and ankle surgery, and the success rate was 95%.<sup>4</sup> The advantages of this technique include control of acute postoperative pain, rapid ambulation, the absence of adverse effects from opioids and nonsteroidal anti-inflammatory drugs,<sup>5</sup> and providing better postoperative analgesia than opioids.<sup>6</sup> In addition, it could improve functional outcomes in the short and medium term.<sup>1</sup>

Our main objective was to describe the supramalleolar ankle block technique performed by a trauma surgeon and the secondary objective was to evaluate our experience with this technique in the last five years.

## MATERIALS AND METHODS

A retrospective observational study of the last five years was carried out. In this period, we operated on 1,714 patients with ankle-foot pathologies, and 1,286 (75%) underwent a supramalleolar ankle block.

Patients with previous surgery, bilateral surgeries, peripheral neuropathy, diabetes, vascular disease or active infection in the area where the local anesthetic injections were applied, and smokers were excluded from the sample. The sample included 771 patients (60%) who had undergone a supramalleolar ankle block before surgery.

### Supramalleolar ankle block technique

The articular and skin sensory innervation of the foot and ankle is given by branches of the femoral nerve and the sciatic nerve, there are five nerves, three of them are superficial: the sural (Figure 1), superficial fibular (Figure 2) and saphenous nerves (Figure 3); and two of them are deep: the anterior (Figure 4) and posterior tibial nerves (Figure 5).<sup>7-9</sup>

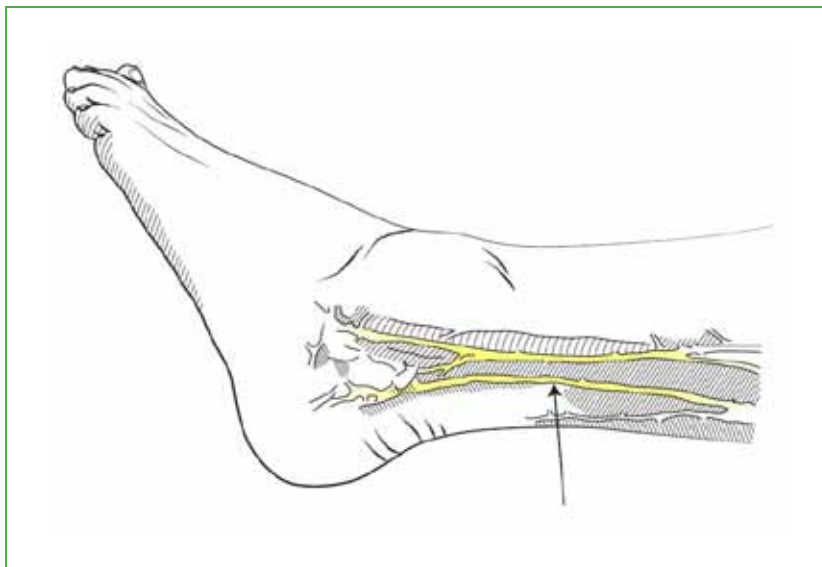
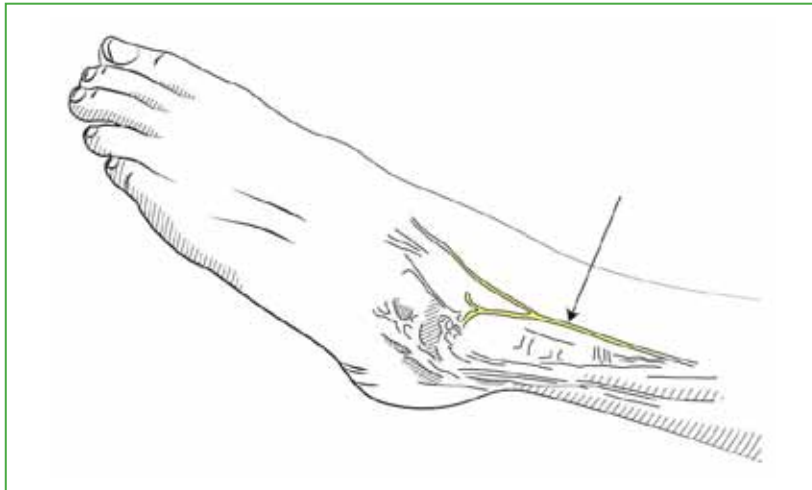
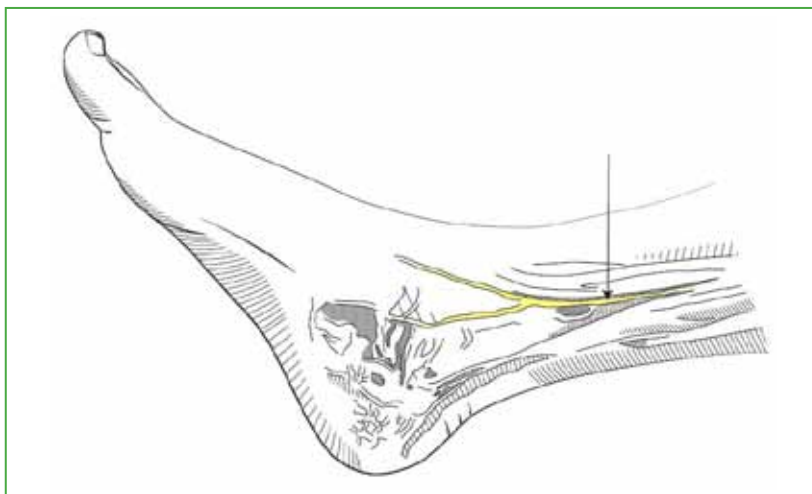


Figure 1. Sural nerve.



**Figure 2.** Superficial fibular nerve.

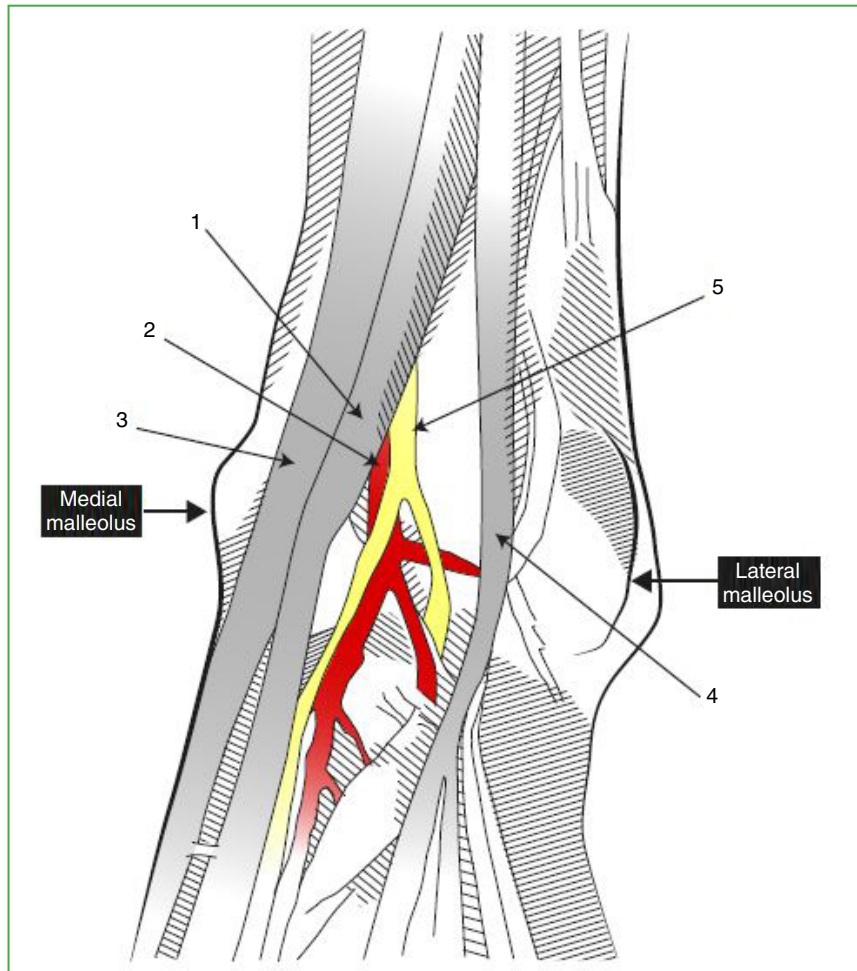


**Figure 3.** Saphenous nerve.

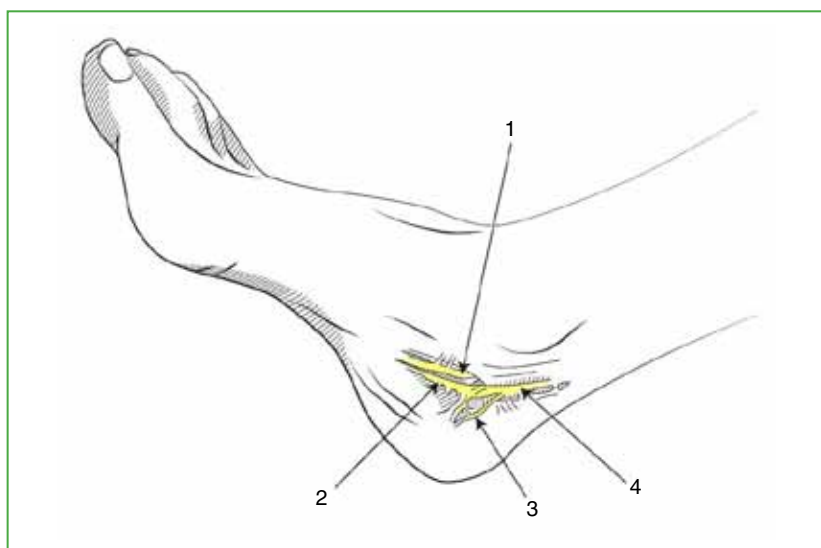
The block is performed with the patient under mild sedation (midazolam) and before placing the tourniquet. The anatomical landmarks are taken into account and it is carried out from medial to lateral: posterior tibial, saphenous, anterior tibial, superficial fibular and sural nerves.

Before injecting the local anesthetic agents, the ankle is washed and disinfected with a 2% chlorhexidine gluconate and 70% isopropyl alcohol solution, and drapes are placed using a sterile technique.

The block is performed at the supramalleolar level, but if it is an ankle arthroscopy, it is more proximal. A combination of 2% lidocaine with 0.5% bupivacaine is administered in equal parts for a final volume of 40 ml. 15 ml are instilled into the posterior tibial nerve, 10 ml into the anterior tibial nerve, and 5 ml into the saphenous, superficial fibular, and sural nerves. The instillation is carried out in a precise way, adjacent to the nerve to be blocked, previously aspirating.



**Figure 4.** Anterior tibial nerve. 1. Extensor hallucis longus; 2. anterior tibial artery; 3. anterior tibial tendon; 4. extensor digitorum longus; 5. anterior tibial nerve.

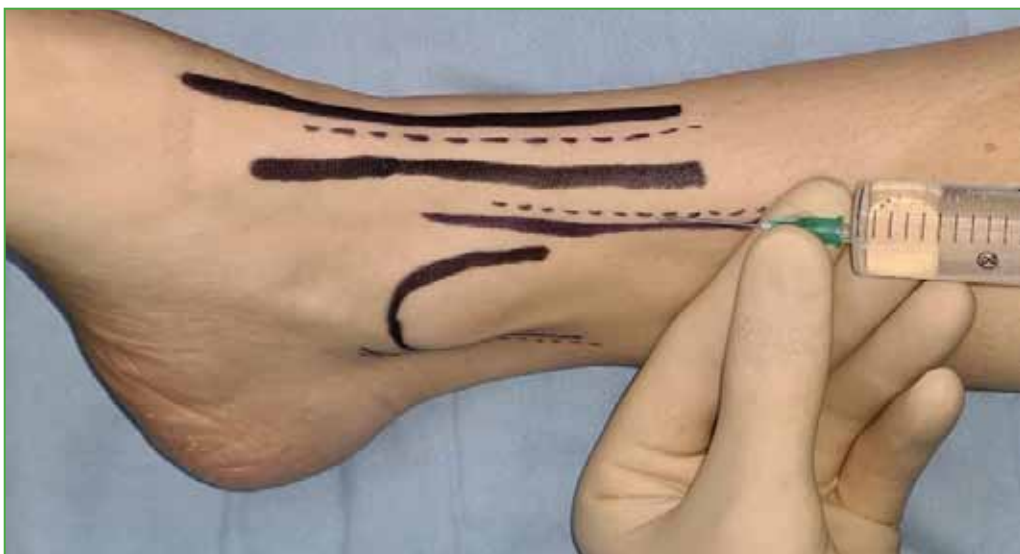


**Figure 5.** Posterior tibial nerve. 1. Medial plantar nerve; 2. Lateral plantar nerve; 3. Calcaneal branches; 4. Posterior tibial nerve.

The patient is placed in the supine position, initially in external rotation, then internal rotation is achieved as all the nerves in the ankle are successively blocked. For the posterior tibial nerve block (15 ml), the leg is rotated externally, the pulse of the posterior tibial artery is taken as reference, and the nerve is located posterior to it (Figure 6). The saphenous nerve (5 ml) is located subcutaneously adjacent to the saphenous vein (Figure 7); the anterior tibial nerve (10 ml) is located deep in the anterior aspect of the tibia between the extensor hallucis longus tendon and the tibialis anterior (Figure 8). The superficial fibular nerve (5 ml) can be visualized directly, at the subcutaneous level, by inverting the foot (Figure 9). The sural nerve (5 ml) is blocked subcutaneously, immediately anterior to the Achilles tendon (Figure 10).



**Figure 6.** Posterior tibial nerve block.



**Figure 7.** Saphenous nerve block.



**Figure 8.** Anterior tibial nerve block.



**Figure 9.** Superficial common fibular nerve block.



**Figure 10.** Sural nerve block.

To start surgery, peripheral vasodilation accompanied by erythema is taken as a reference for the beginning of the action of anesthetic agents, which ensures correct anesthesia and tolerance to the tourniquet placed on the ankle.

The duration of the block was evaluated using pain perception expressed in hours as a marker of its end, along with the visual analog scale (VAS) of pain 24 h after surgery (min. 0 and max. 10), the time until taking the first analgesic (hours) and the degree of patient satisfaction (very satisfied, satisfied, not very satisfied).

Each patient was given a form before surgery and reminded, via phone call, to complete it. The complete forms with the data of each patient were collected in the first postoperative control.

## RESULTS

Of the 771 patients included in this study, 418 were women and 353 men. The average age was 47 years (min. 17, max. 88). The [Table](#) details the diseases treated and the procedures performed with this blocking technique.

**Table.** Conditions treated and procedures performed.

Forefoot	Bunionette	17
	Metatarsalgia	30
	Hallux valgus	205
	Hallux rigidus	21
	Hallux varus	7
	Hallux arthroplasty	9
	Lesser toe surgery	34
	Fractures	16
	Brachymetatarsia	3
	Soft tissue	2
	<b>Total</b>	<b>344</b>
Midfoot	Arthrodesis	18
	Fractures	38
	Soft tissue	7
	Accessory navicular	6
	Flatfoot	19
	<b>Total</b>	<b>88</b>
Hindfoot	Haglund's syndrome	14
	Fractures	41
	Arthrodesis	32
	Tarsal coalition	7
	Soft tissue	2
	<b>Total</b>	<b>96</b>
Ankle	Arthroscopy	43
	Fracture	96
	Arthrodesis	29
	Arthroplasty	6
	OATS	7
	<b>Total</b>	<b>181</b>
Tumors	<b>Total</b>	<b>35</b>
ROM	<b>Total</b>	<b>27</b>

OATS = osteochondral autograft transfer system, ROM = removal of osteosynthesis material.

All had complete analgesia for at least 12 h (mean duration: 18 hrs., min. 12 hrs, max. 24 hrs) (Figure 11), the average score in the VAS after 24 hrs was 1.4 (min. 0, max. 3), the average time until taking the first analgesic was 16 h after surgery (min. 13 h, max. 26 h) (Figure 12).

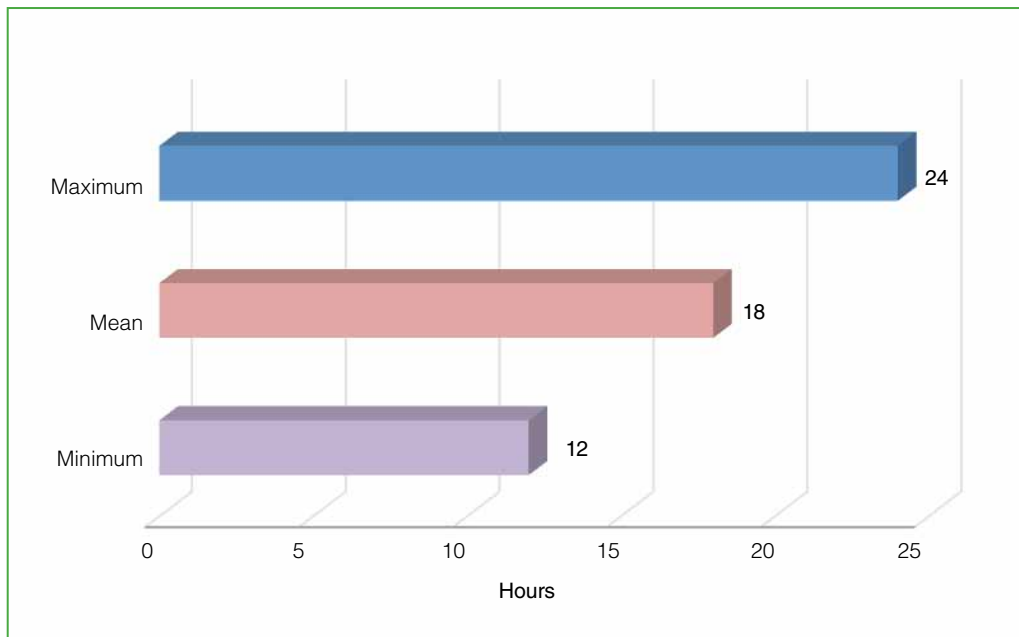


Figure 11. Block duration (hours).

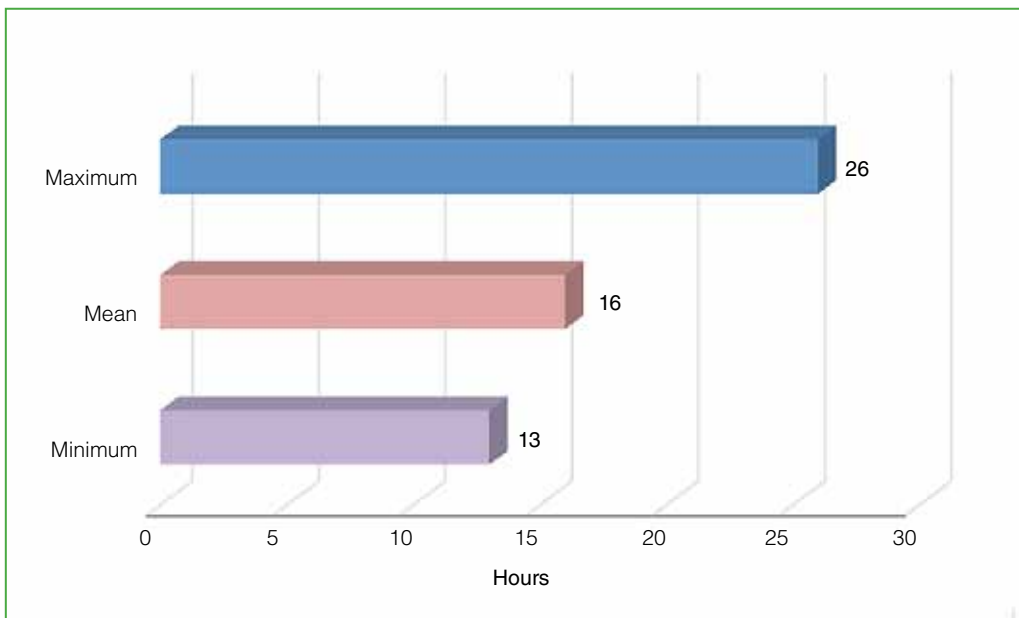


Figure 12. Time until administration of the first analgesic dose (hours).

Regarding the degree of satisfaction with the block and the pain perceived in the first 24 h, 89% were very satisfied; 10% satisfied and 1% not very satisfied.

One patient had paresthesia in the region of the anterior tibial nerve (first interdigital space), which persisted for six weeks, and did not require pharmacological or surgical treatment. There were no cases of systemic toxicity from local anesthetics, or infection at the infiltration site.

## DISCUSSION

Peripheral block allows surgery to be performed in high-risk patients and thus reduces the possible complications of general anesthesia. The advantages of the ankle block include control of acute post-surgical pain, rapid ambulation and mobilization,<sup>1,2,5</sup> and providing better post-surgical analgesia than opioids.<sup>6</sup> In addition, it could improve functional outcomes in the short and medium term.<sup>1</sup>

The ankle block inhibits the acute pain signal from the surgical site to the spinal cord and decreases central nervous system sensitization.<sup>10</sup> In this way, it contributes to extending the time until postoperative analgesics are taken, reducing the required dose, and preventing side effects associated with their use.<sup>1,2</sup>

Likewise, they improve the scores of postoperative pain and patient satisfaction. Inadequate management of postoperative pain is a risk factor for the development of chronic pain and may influence the appearance of poor functional outcomes.<sup>11</sup>

In 1983, Sarrafian et al. published a series of 50 cases of distal peripheral ankle block with bupivacaine administered by an anesthesiologist. They reported an onset of action of approximately 20-25 min and a duration of 10-25 hours.<sup>5</sup> Myerson et al. described a series of 1,295 patients who were administered a combination of lidocaine and bupivacaine for the block. The average duration of the block was 9 hrs (min. 6 hrs, max. 28 hrs) and the rate of patient satisfaction with the procedure was 87%.<sup>4</sup>

Kir et al. carried out a study in 60 patients to compare the VAS score and the time until taking the first analgesic in patients who underwent general anesthesia alone and in those who received, in addition to general anesthesia, an ankle block with bupivacaine in charge of an anesthesiologist. They recorded the VAS score at 24 h and the average result was 1.3 for patients with block. They also reported a longer delay before taking the first analgesic in this same group, although they did not quantify the record.<sup>1</sup>

In our study of 771 patients, complete analgesia lasted an average of 18 hours and the average VAS score 24 hours after surgery was 1.4, with a patient satisfaction rate of more than 90% with respect to the perceived pain in the first 24 hours. When comparing our results with those of other case series, ours coincide with all the determined parameters.<sup>1,4,5</sup>

Peripheral block is performed under minimal sedation, the American Society of Regional Anesthesia and Pain Medicine (ASRA) does not recommend it with deep sedation, since possible signs of nerve damage are absent,<sup>12</sup> and recommends its administration before placing the tourniquet.

For the ankle block, we administered a combination of 2% lidocaine with 0.5% bupivacaine in a total volume of 40 ml. This combination of anesthetic agents, added to the volume, allowed us to block the nerves through imbibition and thus avoid traumatic injuries. We also did not seek to generate paresthesia to locate the nerves, as this would increase the chances of neurovascular damage.<sup>5</sup> The incidence of long-term nerve injury symptoms is 0.7%.<sup>2,13,14</sup>

Other described complications include systemic toxicity from local anesthetics, whose incidence ranges from 7.5% to 20% per 10,000 blocks<sup>2,13,14</sup> and infection at the injection site, an infrequent complication and, to a large extent, associated with continuous infusion catheters in hospitalized patients (incidence 0-3.2%).<sup>2,12,14</sup>

When performing the ankle block with the combination of anesthetic agents before surgery, rapid-onset anesthesia is achieved; lidocaine has a latency time of between 3 and 10 min<sup>13,14</sup> and the duration is long, because the action time of bupivacaine is between 400 and 450 min,<sup>13,14</sup> which makes it possible to perform outpatient surgeries with greater comfort for the patient, reduce the consumption of analgesics in the postoperative period, prolonging the time until taking the first analgesic and thus avoiding its possible complications. The degree of satisfaction with analgesia during the first 24 h of the postoperative period is high.

## CONCLUSION

Supramalleolar ankle block is an effective and safe method that can be performed by the orthopedic surgeon in charge of surgery to obtain prolonged postoperative analgesia with a high degree of patient satisfaction.

Conflict of interest: The authors declare no conflicts of interest.

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# Role of Prosthetic Alignment and Heterotopic Calcifications in Total Ankle Arthroplasty

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## ABSTRACT

**Introduction:** The main objective of this work is to evaluate the relationship between the formation of heterotopic calcifications and the alignment parameters of the prosthesis. **Materials and Methods:** The population under study comprised 31 patients. The radiographic alignment variables evaluated were alpha and beta angles, the talar center of rotation, and the percentage of posterior coverage of the tibia in the immediate postoperative period and after 2 years. The clinical evaluation variables were: VAS, AOFAS, and the SF-36 questionnaire to evaluate quality of life at the end of follow-up. **Results:** The most frequent etiology of osteoarthritis was post-traumatic (67.7%). In the immediate postoperative period, the mean alpha angle was 88.7° (range 82-92.6°; SD± 2.61); the mean beta angle was 84.46° (range 78°, 62-91.40°; SD ±3.59). The alignment of the tibial component in the anteroposterior plane was neutral in 25 patients (80.6%), valgus in 6 (19.4%), and varus in none. At 2 years of follow-up, 96% presented heterotopic calcifications. An improvement was verified both in the AOFAS (pre/post 31.90/80.94) and in the VAS scales (pre/post: 8.7/1.97) (p<0.05). **Conclusions:** No relationship was found between heterotopic calcification and worse functional outcomes or pain, except for quality-of-life parameters (SF-36) such as physical condition, emotional limitation, and general health perception, which worsened as the degree of calcifications around the prosthesis increased.

**Keywords:** Alignment, heterotopic calcifications, quality of life

**Level of Evidence:** IV

## Rol de la alineación de la prótesis y las calcificaciones heterotópicas en la artroplastia total de tobillo

### RESUMEN

**Introducción:** El objetivo principal fue evaluar la relación entre la formación de calcificaciones heterotópicas y los parámetros de alineación de la prótesis. **Materiales y Métodos:** La población estaba formada por 31 pacientes. Se evaluaron variables radiográficas de alineación, como ángulos alfa y beta, centro de rotación astragalino y el porcentaje de cobertura posterior de la tibia en el posoperatorio inmediato y a los 2 años. Las variables de evaluación clínica fueron: la escala analógica visual y la escala de la AOFAS, y el cuestionario SF-36 para evaluar la calidad de vida al final del seguimiento. **Resultados:** La etiología más frecuente de la artrosis fue la postraumática (67,7%). En el posoperatorio inmediato, el ángulo alfa promedio fue de 88,7° (rango 82-92,6; DE ± 2,61); el ángulo beta, de 84,46° (rango 78,62-91,40; DE ± 3,59). La alineación del componente tibial en el plano frontal fue neutra en 25 pacientes (80,6%), en valgo en 6 (19,4%) y en varo (0%). A los 2 años de seguimiento, el 96% tenía calcificaciones heterotópicas. Mejoraron los puntajes en la escala de la AOFAS (preoperatorio/posoperatorio: 31,90/80,94) y en la escala analógica visual (preoperatorio/posoperatorio: 8,7/1,97) (p <0,05). **Conclusiones:** No se halló una relación entre calcificaciones heterotópicas y peores resultados funcionales ni de dolor, excepto en los parámetros de calidad de vida (SF-36), como el rol físico, la limitación emocional y la percepción de la salud general, que empeoraron a medida que aumentó el grado de calcificaciones alrededor de la prótesis.

**Palabras clave:** Alineación; calcificaciones heterotópicas; calidad de vida.

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## INTRODUCTION

Heterotopic calcification (HC) is a frequent phenomenon after a total ankle replacement: the published incidence oscillates between 3.8% and 82%,<sup>1</sup> and can even reach 100%.<sup>2</sup> The cause remains unclear. Some authors have linked it to age, male sex, surgical time, the osteoarthritis's etiology, and the prosthesis's lack of bone coverage.<sup>3-5</sup>

One theory,<sup>3</sup> based on Wolff's law, suggests that the ankle's larger misalignment could generate more tension in the surrounding soft tissue and, hence, more calcification. In turn, these neoformations could impact functional clinical outcomes. However, little is known about the relationship between prosthesis alignment and HC formation.

The main objective of this study was to evaluate the relationship between HC formation and the alignment parameters of the prosthesis. The secondary objectives were evaluating the relationship between the HCs and assessing clinical outcomes.

## MATERIALS AND METHODS

This retrospective series presents >18-year-old patients who underwent a third-generation ankle arthroplasty between 2007 and 2018. Patients with incomplete clinical or radiographic records, <2 years of follow-up, and revision surgeries were excluded.

The demographic variables evaluated were sex, age, body mass index, and comorbidities.

### Clinical analysis

Before the operation, the history of surgeries on the same ankle or foot, and the etiology of osteoarthritis were assessed. We also used the visual analog scale (VAS) for pain and the AOFAS scale (*American Orthopaedic Foot and Ankle Society*) before surgery and after two years. At the end of follow-up, quality of life was evaluated with the SF-36 health survey. The patients who suffered some kind of complication during follow-up, as well as the indicated treatment, are specified.

### Radiographic analysis

Weight-bearing anteroposterior and lateral ankle radiographs were taken before surgery and in the immediate postoperative period (week 4), and after one and two years. All radiographic measurements were taken by three orthopedists.

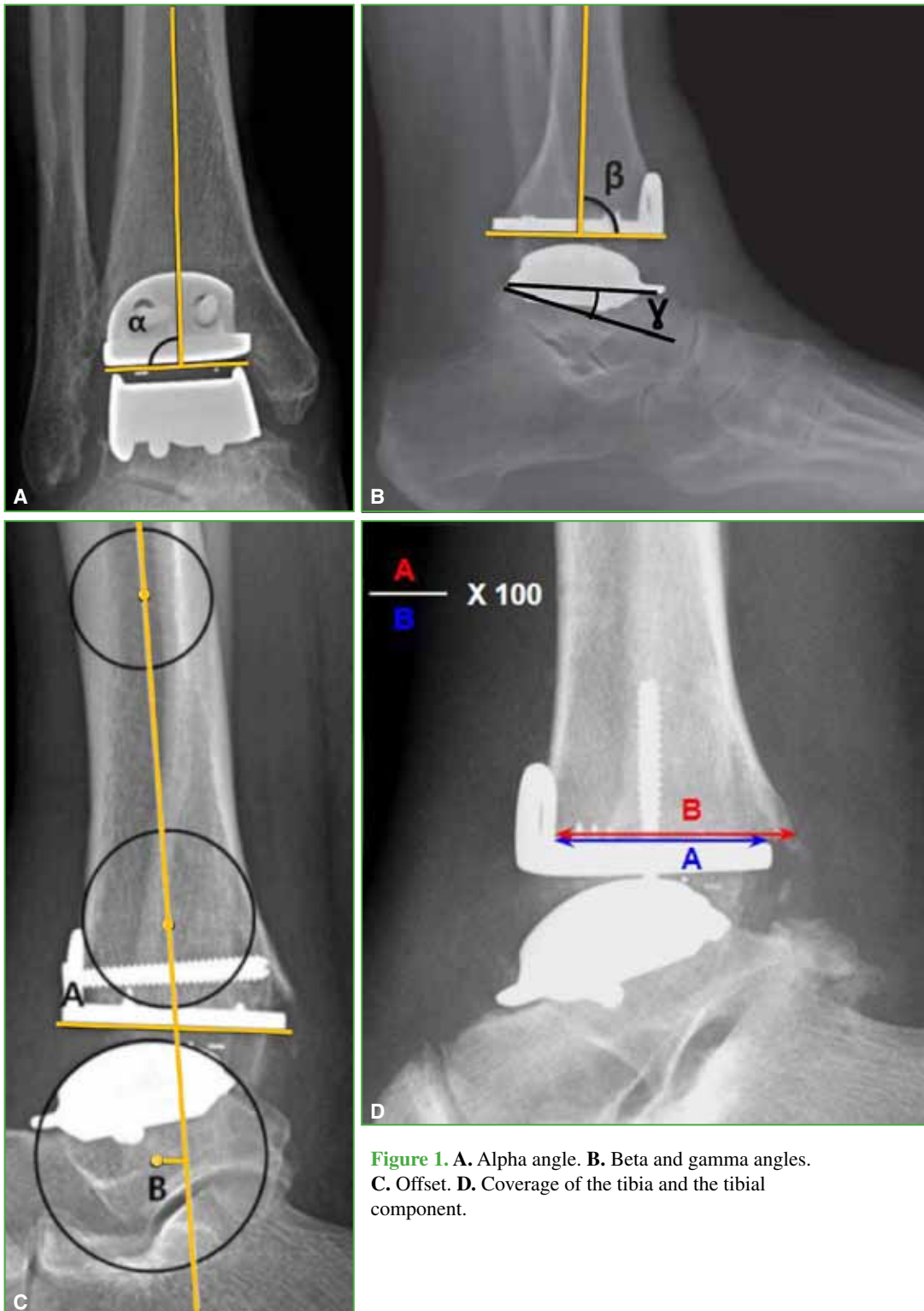
The radiographs' angle parameters were evaluated in the immediate postoperative period, and after one and two years, to assess potential changes through time.

To study prosthesis alignment in the frontal plane, the alpha angle was taken<sup>6</sup> (varus: >92, valgus: <86)<sup>7</sup>; for tibial inclination in the lateral radiograph, the beta angle was used<sup>6</sup>. The positive value was set at <86°, while diminutions (>92°) were considered negative values.<sup>7</sup>

The position of the center of rotation of the talus, the offset of the prosthesis, was evaluated in relation to the longitudinal axis of the tibia in the lateral projection<sup>8</sup>; it can be placed ahead of the axis of the tibia (positive), behind it (negative), or in the center (neutral) (Figure 1).

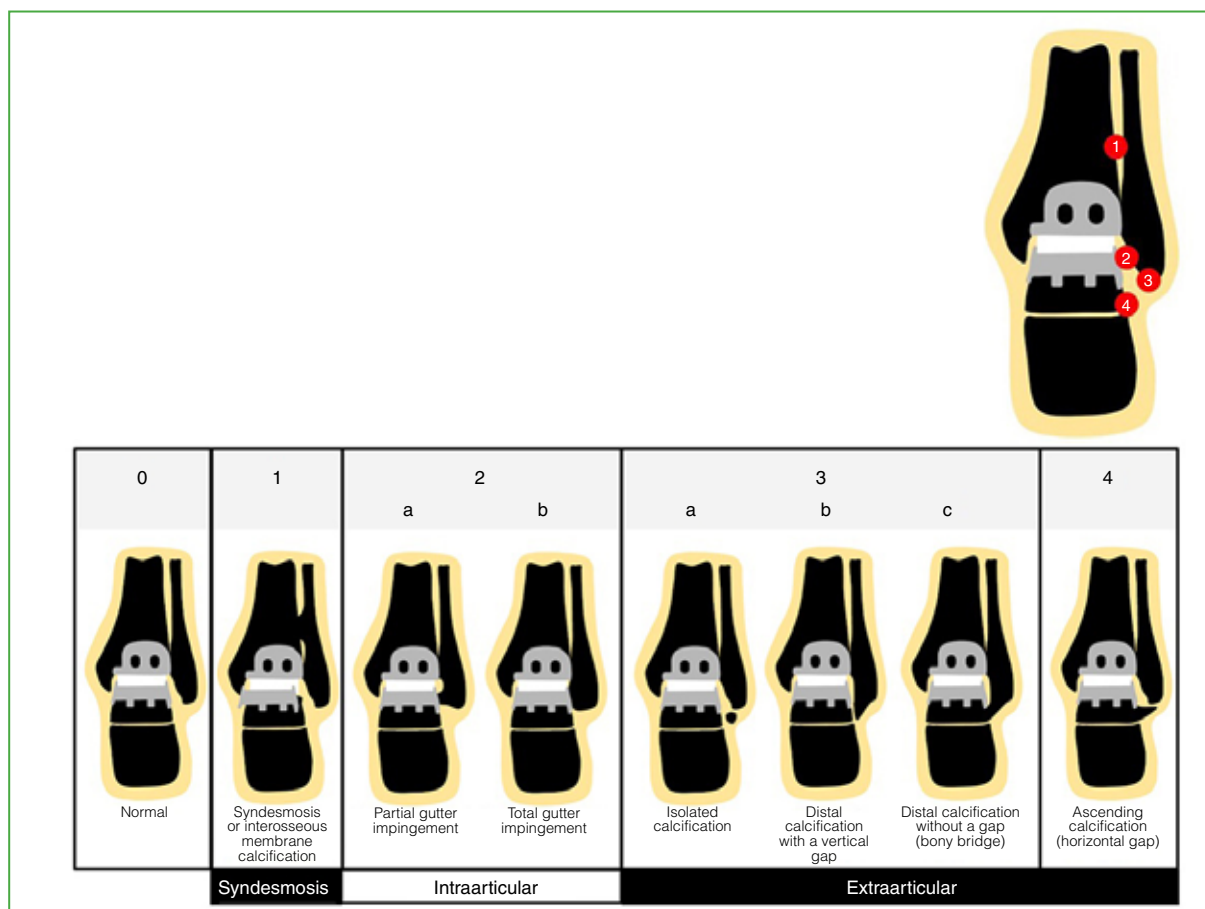
The size ratio between the tibial component of the prosthesis and the tibia itself was also analyzed, using an adaptation we have developed for the Hintegra® prosthesis, based on those created by other authors.<sup>3,5,9</sup> The aim was to quantify the degree of posterior coverage or lack thereof.

The size ratio of the tibia and the tibial component of the prosthesis (coverage) was assessed in the lateral radiograph of the immediate postoperative period. Two lines parallel to the tibial component were drawn: one from the posterior edge of the tibial component's anterior wall to the component's posterior edge (line A), and the other up to the tibial line's posterior cortex (line B). The ratio was measured based on both lines (line A/line B x 100), resulting in the coverage percentage. It is considered to be 100% when both edges of the tibia and the tibial component are aligned along the vertical axis. Any value exceeding 100% is considered an over-coverage (the prosthesis protrudes posteriorly), while any value below 100% is an under-coverage (the tibia protrudes posteriorly).



**Figure 1.** A. Alpha angle. B. Beta and gamma angles. C. Offset. D. Coverage of the tibia and the tibial component.

HC was defined as any bone neoformation in the postoperative radiographs (anteroposterior and lateral) after six weeks of surgery.<sup>3</sup> Said calcifications were evaluated with radiographs one and two years after the intervention. These radiographs were compared to those of the immediate postoperative period, with the aim of ruling out the presence of postoperative remnant osteophytes and distinguishing them from those neoformations. In the lateral projection, they were evaluated using Brooker's classification (as modified by Choi *et al.*<sup>10</sup>) for the posterior compartment, and Jung *et al.*'s<sup>11</sup> classification for the anterior compartment. With the purpose of describing them in the anteroposterior plane, we have developed a topographic classification as an attempt to standardize their description in this plane (Figure 2).



**Figure 2.** Descriptive classification of heterotopic calcifications in the coronal plane.

We propose a topographic classification of HC associated with ankle arthroplasty which seeks to describe the position of said calcifications in the coronal plane. Since the independent impact of each bone neoformation's position on clinical outcomes is unknown, this classification does not describe severity.

It is divided into four zones that can be subdivided. The zones are numbered incrementally from the most proximal, which is the syndesmosis (zone 1), ascending through the gutter (zone 2) and the inframalleolar region (zone 3), until the most distal, which is the talar (zone 4). In turn, medial calcifications were called M and lateral calcifications were called L. The patients with two or more ossifications are described independently, with their respective nomenclature. Calcifications in zones 1 and 2 are considered intra-articular, while those located in zones 3 and 4 are considered extra-articular. Within zone 2, we propose one subtype that compromises the gutter partially (a) and a second subtype that compromises it totally (b). In turn, zone 3 was subdivided into ossifications with no direct contact with other bones, in isolated form (a); those which continue towards the tip of the malleolus (b); and those which form a complete bony bridging between the malleolus and the talus (c).

## Surgical technique

All arthroplasties were performed with the same third-generation prosthesis model (Hintegra®, Integra, Plainsboro, New Jersey/New Deal, Lyon, France). The surgeries were practiced by the same surgical team. Additional procedures were added to the original technique when necessary (ligament reconstruction, Achilles tendon lengthening, etc.).

## Statistical analysis

Regarding descriptive statistics, the absolute and relative frequencies of qualitative variables were calculated and entered into double-entry tables, calculating them by column. The mean, median, and standard deviation of the quantitative variables were also calculated.

The relationships between categorical variables were investigated using Pearson's  $X^2$  test, whenever possible; when not possible, Fisher's exact statistical was calculated in the 2x2 tables.

To analyze the difference between quantitative variables, we used the nonparametric Mann-Whitney U test for independent samples and the Kruskal-Wallis test for larger groups; in both cases, this was due to the impossibility of supposing the normality of data distribution.

The SPSS, Windows v. 22 program was used for statistical analysis, and the Excel program, to draw graphics and tables. A  $p = 0.05$  value was considered statistically significant.

## RESULTS

Out of 61 patients treated with total ankle arthroplasty in our Center, 30 (49%) did not complete the follow-up, which left a total of 31 for the study. The average age was 55.8 years (range 87-32,  $SD \pm 14.6$ ). There were no bilateral cases. Fifteen (48.4%) arthroplasties were performed on right ankles and 16 (51.6%) on left ankles.

Three patients (9.7%) were diabetic; three (9.7%) were smokers; and four (12.9%) had rheumatoid arthritis. The average body mass index of the population was  $27.9 \text{ kg/m}^2$  ( $SD \pm 4.3$ ). Nineteen (61.3%) had previous ankle surgeries.

The most frequent etiology of osteoarthritis was post-traumatic (67.7%; 21 cases).

Additional procedures were performed on 16 patients (51.6%): six (19%) on bone tissue and 10 (23.3%) on soft tissue.

Five patients (16.1%) suffered complications: two (6.4%), an intraoperative fracture of the inner malleolus, which required fixation during the surgery itself, and three, postoperative complications: a fracture of the medial malleolus which required reduction and osteosynthesis, one wound dehiscence which improved with topic treatment, and one stress fracture of the fifth metatarsal which was treated with a Walker boot. No cases required revising the arthroplasty.

## Prosthesis alignment

In the immediate postoperative period, the average alpha angle was  $88.7^\circ$  (range 82-92.6;  $SD \pm 2.61$ ) and the average beta angle was  $84.46^\circ$  (range 78.62-91.40;  $SD \pm 3.59$ ).

The alignment of the tibial component in the frontal plane was neutral in 25 (80.6%) patients; out of the rest, six (19.4%) were valgus and 0 (0%), varus. Regarding the alignment in the sagittal plane (beta), it was neutral in 14 (43.4%) patients and positive in 17 (54.8%); there were no negative values.

Regarding the center of rotation of the talus in relation to the longitudinal axis of the tibia (offset), the alignment was neutral in nine (29%) patients, ahead of the axis in 22 (71%), and none behind.

In 19 (61%) patients, a lack of posterior coverage was observed in the immediate radiograph, with an average coverage of 95.26% (range 84-104.17).

The aforementioned variables suffered no statistically relevant modifications throughout the two years of follow-up (Table 1).

**Table 1.** Immediate postoperative alignment in the anteroposterior and lateral planes

Prosthesis alignment	
Alpha angle (mean)	88.69°
Beta angle (mean)	84.74°
Varus	0%
Valgus	19%
Neutral	25%
Negative offset	0%
Neutral offset	29%
Positive offset	71%

### Heterotopic calcifications

The prevalence of HC in the sagittal plane after one year was 0% in the anterior region and 80% in the posterior; the latter increased significantly, up to 96%, after two years of follow-up. Furthermore, not only the incidence but also the degree of calcification increased (Table 2).

**Table 2.** Heterotopic calcifications in the lateral plane

Heterotopic calcifications in the lateral plane		
	1 year	2 years
Brooker 0	19.4%	3.2%
Brooker 1	16.1%	12.9%
Brooker 2	22.6%	6.5%
Brooker 3	29%	32.3%
Brooker 4	12%	45.2%
Jung 0	93.5%	93,5%
Jung 1	6.5%	6,5%
Jung 2	0%	0%
Jung 3	0%	0%
Jung 4	0%	0%

In the coronal plane radiograph, based on the descriptive classification proposed in this study, 22 patients (70.9%) had HC one year after surgery and 29 (93.5%), two years after surgery (Table 3).

**Table 3.** Heterotopic calcifications in the coronal plane

Heterotopic calcifications in the coronal plane		
	1 year	2 years
0	29.03%	6.50%
M3b	22.65%	19.40%
M2a	12.83%	9.70%
M2b	6.45%	12.90%
M3a	6.45%	3.20%
1	3.23%	3.20%
L2b	3.23%	3.20%
L3a	3.23%	3.20%
L3b	3.23%	3.20%
M3a	3.23%	3.20%
M4	3.23%	3.20%
L2a	3.23%	12.00%
M3c	0.00%	16.10%

### Functional outcomes

A statistically relevant improvement was obtained both in the AOFAS scale score (preoperative/postoperative: 31.90/80.94) and in the VAS score (preoperative/postoperative: 8.7/1.97) (Table 4).

Regarding the SF-36 survey, very good results were achieved on pain, and the social and emotional roles, and good results on the physical role, vitality, and general health perception.

**Table 4.** Clinical evaluation

Clinical evaluation			
	Preoperative	Postoperative	p
AOFAS scale	32	81	<0.005
VAS	9	2	<0.005

AOFAS = American Orthopaedic Foot and Ankle Society; VAS = visual analog scale.

### Correlations

Patients with primary osteoarthritis presented a higher proportion of elevated stages of posterior HC one and two years after the surgery. The proportion of posterior HC was higher in women two years after the surgery, yet both correlations were statistically irrelevant ( $p > 0.05$ ). Higher age was linked to elevated stages of posterior HC two years after surgery, with a statistically significant difference ( $p < 0.05$ ).

No relationship was observed between the tibia's posterior coverage and elevated stages of HC one and two years after surgery; these differences were statistically irrelevant ( $p > 0.05$ ).

Regarding alignment parameters, it was observed that the greater the misalignment in the coronal plane (alpha angle), the greater the degree of HC in the posterior compartment after two years ( $p > 0.05$ ). In the sagittal plane, as the beta angle diminished (augment of lateral tibial inclination), the degree of posterior HC after two years increased. However, both differences were statistically irrelevant. Although we found a relationship between valgus misalignment and elevated stages of HC one year after surgery, this difference was not statistically significant.

There was no statistically relevant relation between AOFAS scale scores and elevated stages of posterior HC. It was observed that the VAS score diminished with the increase of elevated stages of posterior HC two years after surgery, but these differences were statistically irrelevant ( $p > 0.05$ ).

Regarding the SF-36 survey, the average for physical role is lower in elevated stages of posterior HC after two years; emotional limitation and general health perception are lower in elevated stages of posterior HC after two years, and the differences were statistically relevant in the three variables ( $p < 0.05$ ).

71% of the patients had HC in the anteroposterior plane one year after surgery, and 93.5% after two years. 19% presented HC in more than one location after two years.

## DISCUSSION

HC is a frequent phenomenon after a total ankle arthroplasty. It has been related to certain demographic variables and personal precedents. Lee *et al.*<sup>12</sup> state that there are no differences regarding sex, age, body mass index, the cause of osteoarthritis, and previous surgeries. For their part, Valderrabano *et al.*<sup>13</sup> hold that HC is more frequent in patients with post-traumatic osteoarthritis, while Manegold *et al.*<sup>3</sup> found no link between sex or the etiology of osteoarthritis and said ossifications. On the contrary, Choi and Lee<sup>9</sup> observed that the incidence of HC doubled for the male sex. In our study, HC was more frequent in the female sex ( $p > 0.05$ ). Although the most common etiology for osteoarthritis in our patients agrees with the publications (post-traumatic)<sup>13</sup>, no direct relation with the HC was found ( $p > 0.05$ ).

In our study, HC prevalence was 6.5% in the anterior region and 80% in the posterior; the latter increased significantly, up to 96%, after two years of follow-up, coinciding with Manegold *et al.*<sup>3</sup> from 86.4% (76/88) ( $p = 0.002$ ) to 99% (87/88) after three years of follow-up. Besides, in our series, not only the incidence of HC increased, but also its stage (Table 2).

Published reports on HC in ankle arthroplasty are disparate, since some authors do not distinguish between different locations. Most studies are limited to analyzing posterior HC mainly.<sup>12</sup> It is communicated that, often, HC appears as an amorphous shade noticed in the radiograph, from the first month after the surgery onwards.<sup>12</sup> Jung *et al.*<sup>11</sup> published that they could detect HC (in the anterior compartment) from week six on. In 2011, based on a series of 90 operated ankles, Choi and Lee<sup>9</sup> informed that 31 ankles had HC, 30 of which appeared during the first year after surgery. Likewise, some studies revealed that HC appeared within two years after ankle arthroplasty.<sup>9</sup> Lee *et al.*<sup>12</sup> affirmed that the published prevalence of these HC usually oscillates between 3.8% and 82%, and communicated a 25% (20 out of 80 patients) of postoperative HC in a series of patients who had been fitted with a HIntegra® prosthesis. Natens *et al.* found a prevalence of 42% in 26 patients. In the study by Valderrabano *et al.*<sup>13</sup>, 63% of patients had HC; San Giovanni *et al.* communicated an 82% incidence with the Mobility® prosthesis, all of them in the ankle's posterior region. None of those patients required treatment because they presented neither symptoms nor friction syndrome in the ankle.

Regarding posterior HC, it has been published that 40.6% of patients who underwent an arthroplasty with HIntegra® had HC: one case (7.7%), Brooker class 1; two cases (15.4%), Brooker class 2; and 10 cases (76.9%), Brooker class 3.<sup>10</sup> For their part, Haymanek *et al.*<sup>14</sup> observed a 100% of posterior HC (79 patients) at the end of follow-up and informed that classes 2 (31.6%) and 3 (51.9%) were the most relevant, followed by classes 1 (13.9%) and 4 (2.5%). Lee *et al.*<sup>12</sup> published that 25% of their patients operated with HIntegra® presented posterior HC: four Brooker 1 (20%), five Brooker 2 (25%), four Brooker 3 (20%), and seven Brooker 4 (35%). Kerkhoff *et al.*<sup>15</sup> found a 71.6% (73 ankles) incidence in the posterior compartment. In a study with 107 patients, King *et al.*<sup>5</sup> observed 86% of posterior bone growth 18 months after surgery. In our series, the percentage of posterior HC was 80%, with a greater prevalence of the higher stages (Brooker 4), coinciding with the publications of the previously cited authors; in turn, this prevalence increased significantly, up to 96%, after two years of follow-up.

The presence of anterior HC in ankle arthroplasty has also been scarcely studied. Lee *et al.*<sup>12</sup> have explained that, being less frequent, they are less studied and published. These authors analyzed a series of 80 arthroplasties, with only three cases (3.75%) of anterior ossification. In our series, only two patients (6.5%) had anterior HC at the end of follow-up. It could also be the case that the typical anterior wall of the tibial component in the Hintegra® design precluded the formation of said anterior calcifications.<sup>12</sup> So much so that King *et al.*,<sup>5</sup> comparing two populations operated with the Hintegra® and the Salto Talaris® prostheses, observed a greater number of anterior ossifications in patients with the Salto Talaris® prosthesis.

Regarding ossifications in the frontal plane, the scarce studies that mention the incidence of HC in the antero-posterior plane indicate that the prevalence is 56.8% in the medial zone.<sup>15</sup> Lee *et al.*<sup>12</sup> divided the ankle into four quadrants and detected HC in the posteromedial quadrant in five cases (25%); in the posterolateral quadrant, in five cases (25%); in the anteromedial and posterolateral quadrants, in two cases (10%); and in the anterolateral and posteromedial quadrants, in only one case (5%).

Based on the descriptive classification proposed in this study, 22 patients (70.9%) presented HC in the first year after surgery, increasing to 29 patients (93.5%) in the coronal plane after two years; the medial zone was the most frequent location.

As regards the analysis of the ankle's axis, Choi *et al.*<sup>10</sup> found a neutral alignment in 84% of their 32 patients operated with the Hintegra® prosthesis, while 12% were varus and 3%, valgus. King *et al.*<sup>5</sup> add that more prostheses were used with a positive slope (beta angle) than with neutral or negative slopes in the sagittal plane. Haytmanek *et al.*<sup>14</sup> obtained an average alpha angle of 87.8 and an average beta of 87.5. Manegold *et al.*<sup>3</sup> inform that frontal neutral alignment was obtained in 84.1% of cases, while 14.8% were varus and only one prosthesis (1.1%) was valgus. Two-thirds of the patients (59/88; 67%) presented a neutral alignment of the sagittal slope. Although this study found a correlation with the lack of alignment in the anteroposterior plane (varus), it was not statistically relevant.

In our case, with regards to the alignment of the tibial component in the frontal plane, we obtained an anatomical alignment in 25 (80.6%) patients; six (19.4%) were valgus and no case was varus. As for the alignment of the tibial component in the sagittal plane (beta), it was neutral in 14 (43.4%) patients and positive in 17 (54.8%); there were no negative values. Regarding the center of rotation of the talus in relation to the longitudinal axis of the tibia (offset), the alignment was neutral in nine (29%) patients, ahead of the normal axis in 22 (71%), and none behind the axis.

The study of the lack of posterior coverage in the tibia has garnered interest lately, as a consequence of theories that suggest that lack of posterior coverage in the tibial cut would yield greater bone exposure, predisposing to the appearance of posterior ossifications.<sup>11,16</sup> This would explain why they are so frequent in this location.<sup>12</sup> Different ways to measure it according to the various prosthesis models have been described, so there is no standardized measuring method as of yet, making it difficult to compare.

In 2013, King *et al.*<sup>5</sup> reported a mean tibial coverage of 89% (range 73-100) with the Salto Talaris® model, and a negative correlation between the degree of tibial coverage and the formation of hypertrophic bone. In 2011, Choi and Lee<sup>9</sup> analyzed 90 ankles operated with the Hintegra® model and informed that 10 components (11.1%) were small; 79 (87.7%), optimal; and one (1.2%), big. However, they found no significant link between the HC and the degree of coverage. In our series, there were four (12%) cases of over-coverage, eight (25.8%) of normal coverage, and 19 (61%) of under-coverage. The average total coverage was 95.26%. Coinciding with the findings of the cited authors, we have found no significant relationship between lack of coverage and posterior osteogenesis.

In relation to the position of the talar axis of rotation, we had a lower proportion of cases with posterior offset than those published. In a series with the Hintegra® prosthesis, there were eight (25%) cases with neutral offset, 21 (65%) anterior cases, and three (9.4%) posterior cases.<sup>10</sup> Other series inform 27 (30.7%) neutral cases, 28 (31.8%) anterior cases, and 33 (37.5%) posterior cases.<sup>3</sup> In our series, the offset was neutral in nine (29%) patients, anterior in 22 (71%), and posterior in no patients.

As for pain improvement (VAS) after arthroplasty, Jung *et al.*<sup>17</sup> published that the mean pain score diminished from 8.3 to 2.0 in patients with the Hintegra® model. Choi *et al.*<sup>10</sup> communicated an average VAS score of 7.63 prior to surgery and 2.13 after surgery in 22 patients with arthroplasties using the Hintegra® model.

Some authors<sup>9,11</sup> found no association between the degree of HC and clinical outcomes (with neither the VAS nor the AOFAS scores). In our series, a statistically significant improvement was obtained in the VAS score (preoperative/postoperative: 8.7/1.97), with a trend similar to those published and a slight reduction in the VAS score with the increase of advanced stages of posterior HC after two years, although this was not statistically relevant ( $p > 0.05$ ).

It has been extensively described that the AOFAS score improves after ankle arthroplasty. Various authors have published that the AOFAS score improved between the preoperative and postoperative periods, from 46.50 to 81.84, and from 45.7 to 85.2.<sup>10,11</sup> In our series, we observed a statistically relevant improvement of the AOFAS score (preoperative/postoperative: (31.90/ 80.94). As published in some studies,<sup>9,15,18,19</sup> we found no relation between the presence of HC and worse AOFAS scores ( $p > 0.05$ ).

Although the articles that use the SF-36 survey to evaluate the quality of life after a total ankle arthroplasty are scarce,<sup>20,21</sup> we found that the average for physical role is lower in the elevated stages of posterior HC, and that the emotional limitation and general health perception are lower in elevated stages of calcifications, with statistically relevant differences in the three variables ( $p < 0.05$ ).

In a 2020 systematic review,<sup>2</sup> it was stated that the rate of reoperation owing to HC in patients with ankle arthroplasty was 7.2% (range 0-32). Valderrabano *et al.*<sup>13</sup> communicated one of the highest rates of reoperation due to HC, which amounted to 34.2% of the 63% of detected HC in their patients. Other authors published lower rates of reoperation, such as Lee *et al.*<sup>12</sup> (2.5%) and Overley *et al.*<sup>1</sup> (2.3%). In our series, there were no reoperations owing to symptomatic ossifications, just as informed by King *et al.*<sup>5</sup>

The causes of HC formation in arthroplasties are still unknown.<sup>11</sup> It has been proposed that the excessive dissection of soft tissue, bone traumatism, the excess of remnant bone debris during surgery, and the appearance of hematomas could be the origin of said ossifications.<sup>12,22</sup> Some authors hold as well that ankle misalignment after arthroplasty could predispose to these bone neoformations<sup>1</sup>, and that they could be provoked by chronic tension in the ligaments.<sup>2</sup> Based on our experience, our findings and published data, we believe that the factors that predispose to the appearance of such calcifications depend not so much on the patient's variable, but on the variables inherent to the surgical technique and the prosthesis model.

The weaknesses of our study were the small number of patients, which, in some cases, precluded us from making statistical relation inferences; the impossibility to evaluate the range of motion and its relation to the degree of calcifications; and the retrospective design. The tomographic assessment of the HC would be more precise than the radiographic. Regarding the strengths, there are few studies that relate prosthesis alignment with the development of HC. Most evaluations and classifications are described in the sagittal plane, neglecting the coronal plane. We also propose a descriptive classification for the HC in the coronal plane, as there are no publications that deal with this.<sup>23</sup> Our classification will possibly garner the interest these ossifications deserve in future studies.

## CONCLUSIONS

In this study, we detected a high rate of HC two years after surgery, without a clear connection between the different parameters of prosthesis alignment and HC formation. No relation between the presence of HC and worse functional or pain outcomes was found, except for some quality of life parameters (SF-36) —i.e., physical role, emotional limitation, and general health perception— which became worse as the degree of calcifications around the prosthesis increased.

The proposed classification will be useful to describe HCs in the anteroposterior plane, thus enabling their study. We observed that their prevalence is high and that they have been hitherto underestimated, perhaps because there is no classification that allows their proper study.

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# Diabetic Foot and COVID-19 Pandemic in Argentina: Foot and Ankle Specialists Respond to the Use of Telemedicine

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## ABSTRACT

**Introduction:** Telemedicine was the recommendation of international societies during the COVID-19 pandemic for medical consultations in patients with diabetic foot (DF). The main aim of this work is to evaluate the use of telemedicine as a tool for the evaluation and follow-up of patients with DF by foot and ankle specialists in Argentina. As secondary objectives, we propose to assess the satisfaction perceived by the professionals with the use of this tool, to evaluate the specific strategies used to carry out the remote medical consultation, and to determine its permanence when returning to the usual care activity. **Materials and Methods:** Three surveys were sent to members of the Argentine Society of Medicine and Surgery of the Leg and Foot in May and July 2020 and April 2022. **Results:** According to 75% of respondents, the most valuable function of telemedicine was prevention, followed by monitoring of the clinical pathology (54.1%), postoperative follow-up (41.6%), and diagnosis (29.1%). The most commonly used resources for remote consultation were telephone conversations, followed by images sent by instant messaging. Only 37.5% used electronic health record platforms during 2020. **Conclusions:** The most commonly used resources for remote consultation were telephone conversations, followed by images sent by instant messaging. 33.4% of respondents were satisfied with telemedicine consultations in May 2020, while in July, satisfaction with this tool rose to 46.7%. In April 2022, only 13% of those surveyed in July 2020 continued offering remote consultations.

**Keywords:** telemedicine, foot and ankle, diabetic foot, traumatology, COVID-19 pandemic

**Level of Evidence:** IV

## Pie diabético y pandemia de la COVID-19: adaptación al uso de la Telemedicina por los especialistas de pie y tobillo de los Servicios de Traumatología de la Argentina

## RESUMEN

**Introducción:** La telemedicina fue la recomendación internacional durante la pandemia de COVID-19 para las consultas médicas de los pacientes con pie diabético. El objetivo de este estudio fue analizar el empleo de la telemedicina como herramienta en pacientes con pie diabético, por parte de especialistas en pie y tobillo de la Argentina. Como objetivos secundarios se planteó valorar la satisfacción percibida por los profesionales con el uso de esta herramienta, evaluar qué estrategias se usaron para realizar la consulta médica remota y determinar la permanencia al retornar a la actividad asistencial habitual. **Materiales y Métodos:** Se enviaron tres encuestas a los socios de la Sociedad Argentina de Medicina y Cirugía de la Pierna y Pie, entre mayo 2020 y abril de 2022. **Resultados:** La función más valiosa de la consulta remota fue la prevención (75% de los encuestados), el seguimiento clínico (54,1%), el seguimiento posoperatorio (41,6%) y el diagnóstico (29,1%). El recurso más utilizado fue la conversación telefónica, seguida del envío de imágenes por mensajería instantánea. Solo el 37,5% utilizó las plataformas de historia clínica

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virtual. **Conclusiones:** Los recursos más utilizados para la consulta remota fueron la conversación telefónica, seguida del envío de imágenes por mensajería instantánea. El 33,4% estaba conforme con la consulta por telemedicina en mayo de 2020, mientras que, en julio, la conformidad ascendió al 46,7%. En abril de 2022, solo el 13% continuaba con las consultas remotas.

**Palabras clave:** Telemedicina; pie y tobillo; pie diabético; traumatología; pandemia; COVID-19.

**Nivel de Evidencia:** IV

## INTRODUCTION

Argentine Republic Decree No. 297/2020<sup>1</sup> of March 2020 for the “preventive and compulsory social isolation” implied the application of restrictions to all non-urgent medical consultations. Thereafter, providing care to people with diabetic foot in the way recommended by the guidelines and available evidence was not possible and this required the search for alternative ways to provide adequate follow-up to patients, avoiding or decreasing the attendance of high-risk patients in health centers. Trauma services, and specifically the foot and ankle sectors, had to adapt to this new reality, adopting patterns from recent experiences in other countries that had already begun with pandemic restrictions.<sup>2-4</sup>

Telemedicine is defined by the World Health Organization as the provision of healthcare services by health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities.<sup>5</sup>

Diabetic patients are a population at risk and decreasing their attendance at health centers became imperative to avoid contagion. The use of telemedicine is a strategy related to this purpose, which not only allows the clinical monitoring of the patient, but also provides preventive measures.<sup>6,7</sup> It is the recommendation of international societies for the care of this group of patients in this context.<sup>6,8</sup> The COVID-19 crisis resulted in a complete modification of the ways of providing healthcare, both in and out of hospital, in order to be able to attend to the massive influx of COVID patients. In order to prevent at-risk patients from attending hospitals, specialist diabetic foot staff were forced to seek a follow-up solution in the technology, despite insufficient or contradictory evidence about its effectiveness. However, before the current crisis, the role of telemedicine in disasters, military medicine and rural care was already in sight.<sup>9</sup> In Argentina, the development of Telesalud (Telehealth) began approximately 20 years ago, at the Pediatric Hospital “Prof. Dr. Juan P. Garrahan”, for the communication between health institutions that are part of the network, seeking a second opinion, a consultation on a specialty that does not exist in the public hospital attended by the patient or a study that requires more technology than is available in that care center. It is also useful for the follow-up of patients who have already received care away from their homes. Currently, we have the Red Federal de Telesalud y Comunicación a Distancia (*Federal Telehealth and Distance Communication Network*) under the Ministry of Health. This network allows first-opinion consultations for patients and second-opinion consultations for professionals.<sup>10,11</sup> Teleconsultation had already been proposed for wound follow-up and, recently, the role of teledermatology in the pandemic has been reported.<sup>12,13</sup> To date, we have not found any publications on the use of telemedicine by foot and ankle trauma teams specialized in diabetic foot in our region.

The technologies used for teleconsultation must ensure the quality, security and protection of personal and sensitive data, as established by Act No. 25,326. It is recommended that the technology used has the standards for health information systems and security and cybersecurity protocols for the inviolability of information.<sup>14,15</sup> Development of this modality and implementation by the health team were abrupt during the beginning of the pandemic; in some cases, it was necessary to resort to informal communication channels, such as instant messaging, to avoid the cessation of medical care for this group of patients.<sup>16,17</sup>

Therefore, the main objective of this study was to analyze the use of telemedicine as a tool for the evaluation and monitoring of patients with diabetic foot by teams made up of foot and ankle specialists from Argentina. As secondary objectives, we propose to assess the satisfaction perceived by professionals with the use of this tool, evaluate which specific strategies were used for remote medical consultation, and determine the permanence of teleconsultation when returning to usual care activity.

## MATERIALS AND METHODS

Two surveys developed with the Google Drive document creation tool (Google Inc., Menlo Park, CA, USA) were sent to all members of the Sociedad Argentina de Medicina y Cirugía de la Pierna y Pie (SAMECIPP, *Argentine Society of Medicine and Surgery of the Leg and Foot*), in order to obtain data on the implementation of telemedicine as a tool for the evaluation, diagnosis, and monitoring of patients with diabetic foot.

The surveys, once approved by the evaluation committee of the SAMECIPP board of directors, were sent by email to all members. The first one was sent at the beginning of the pandemic (May 2020) and the second one, around the time of the exponential increase in the number of cases (July 2020).

The inclusion criteria were: trauma specialists, members of SAMECIPP, who carry out regular and specific consultations of diabetic foot at the time of responding to the survey. Incomplete or inconsistent surveys were excluded.

The variables surveyed were:

- Healthcare center where they develop their professional activity: free text.
- City: free text.
- Healthcare level of the center: selection of an option (primary, secondary or tertiary).
- Using telemedicine before the pandemic: selecting an option (Yes-No).
- Telemedicine use at the time of the survey: selecting an option (Yes-No).
- Frequency of controls with this modality: selection of an option (0, 1 to 5, 6 to 10, 1 to 20 and more than 20 weekly consultations).
- Tools for remote consultation: selection of one or more options (telemedicine or electronic health record platform, WhatsApp®, telephone or other option to complete).
- Resources used during remote consultation: selection of one or more options (telephone conversation, email, text message, photo, videos, caregiver interview, or other option to complete).
- Consideration of the most valuable function of the tool: selection of one or more options (prevention, diagnosis, treatment, study request, clinical follow-up, postoperative follow-up, or other option to complete).
- Conformity with the information obtained and the guidelines indicated during the teleconsultation: selection of an option (Yes-No).
- Satisfaction with the remote consultation: open response; the responses were grouped into categories: satisfied, partially satisfied, dissatisfied, or does not apply/does not answer.

In addition, the second survey included a question to analyze whether remote consultation increased or decreased in July in comparison to April: selecting an option (Yes-No).

Regarding the third survey in April 2022, it was reported whether specialists continued to conduct telemedicine consultations on diabetic foot.

The data obtained (categorical variables) are expressed as absolute presentation number and percentage.

## RESULTS

The surveys were sent to 218 SAMECIPP members. Thirty-nine professionals from 28 centers met the inclusion criteria in the first survey (Tables 1 and 2).

Six specialists (15%) conducted telemedicine consultations before the pandemic. Twenty-four of the professionals surveyed (61.5%) offered telemedicine consultations for diabetic foot in April 2020. Sixteen (66.6%) of these 24 professionals had 1 to 5 weekly consultations; four of them (16%), 5 to 10 and another four (16%), less than one weekly consultation. The most frequently used tool was sending images through WhatsApp® (WhatsApp Inc., 2009) in 21 cases (87.5%), followed by the chosen virtual medical record platforms (9 cases, 37.5%) and phone calls (7 cases, 29.1%). Regarding the resources for teleconsultation, 21 professionals (87.5%) preferred telephone conversation and the use of photographic images and 45.8% also used video images.

**Table 1.** Data by care facility (n = 28)

Level of care	n (%)
Primary, n (%)	25 (89.3)
Secondary, n (%)	2 (7.1)
Tertiary, n (%)	1 (3.6)
Exclusive diabetic foot office in the Orthopedic Service, n (%)	27 (96.4)
<b>Province</b>	
Autonomous City of Buenos Aires, n (%)	11 (39.2)
Buenos Aires, n (%)	8 (28.6)
Neuquén, n (%)	2 (7.1)
Misiones, n (%)	2 (7.1)
Santa Fe, n (%)	1 (3.6)
Entre Ríos, n (%)	1 (3.6)
Salta, n (%)	1 (3.6)
Córdoba, n (%)	1 (3.6)
Corrientes, n (%)	1 (3.6)

**Table 2.** Demographic data.

	Specialists (n = 39)
Male, n (%)	36 (92)
<b>Professional activity</b>	
Public sector, n (%)	29 (74.3)
Public and private sector, n (%)	7 (17.9)
Private sector, n (%)	3 (7.8)
<b>Region</b>	
Autonomous City of Buenos Aires, n (%)	15 (38.5)
Buenos Aires (province) n (%)	11 (28.3)
Córdoba, n (%)	3 (7.7)
Mendoza, n (%)	2 (5.2)
Santa Fe, n (%)	1 (2.9)
San Juan, n (%)	1 (2.9)
Salta, n (%)	1 (2.9)
Neuquén, n (%)	1 (2.9)
Río Negro, n (%)	1 (2.9)
Entre Ríos, n (%)	1 (2.9)
Tucumán, n (%)	1 (2.9)

Figure 1 details the telemedicine functions reported by respondents, the most valuable function being prevention (75%).

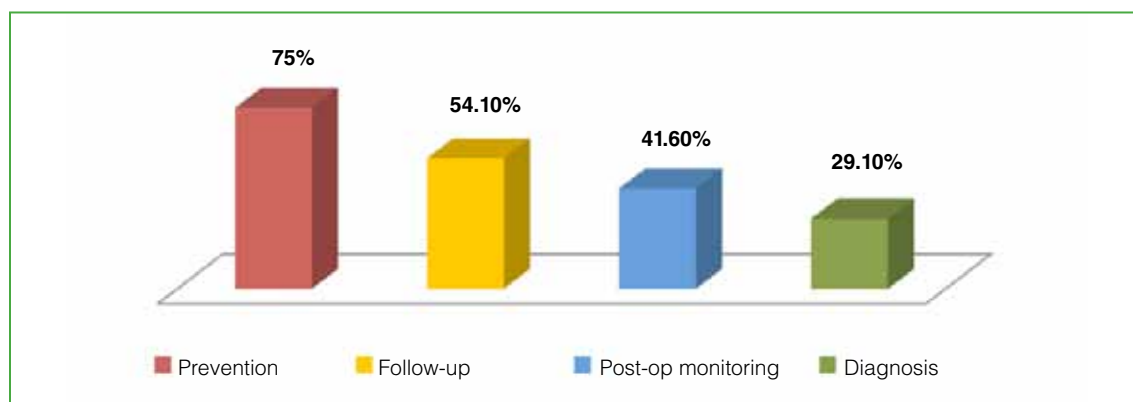


Figure 1. Main functions of telemedicine communicated by professionals during the pandemic.

Regarding compliance with the information obtained and the guidelines indicated during the teleconsultation, 13 specialists (54.1%) said they were satisfied. Seven (29.1%) said they were satisfied with telemedicine; 10 (41.6%) said they were partially satisfied; five (20.8%) said they were dissatisfied and two (8.3%) did not answer. The most common reason for dissatisfaction was the inability to perform the physical examination.

In July 2020, the second survey was sent. Twenty-two foot and ankle specialists answered it (56.4% of the respondents of the first edition), belonging to 17 centers. Fifteen (68.2%) used telemedicine at the time of the survey; seven (31.8%) did not conduct remote consultations. Among specialists conducting remote consultations: nine (60%) used teleconsultation more than in April 2020; three (20%) maintained the same number of consultations and, in three cases (20%), these decreased. Seven (46.7%) were satisfied with the remote consultation; three (20%), were partially satisfied; four (26.7%) were dissatisfied; and one (6.6%) did not answer. If we take into account the response of these same specialists in the first survey: five (33.4%) were satisfied; seven (40%) were partially satisfied; two (20%) were partially satisfied; and one (6.6%) did not answer. Three remained satisfied in both surveys and two remained dissatisfied. None of the respondents who were satisfied in the first survey were dissatisfied in the second; nor did any of the dissatisfied respondents become satisfied (Figure 2).

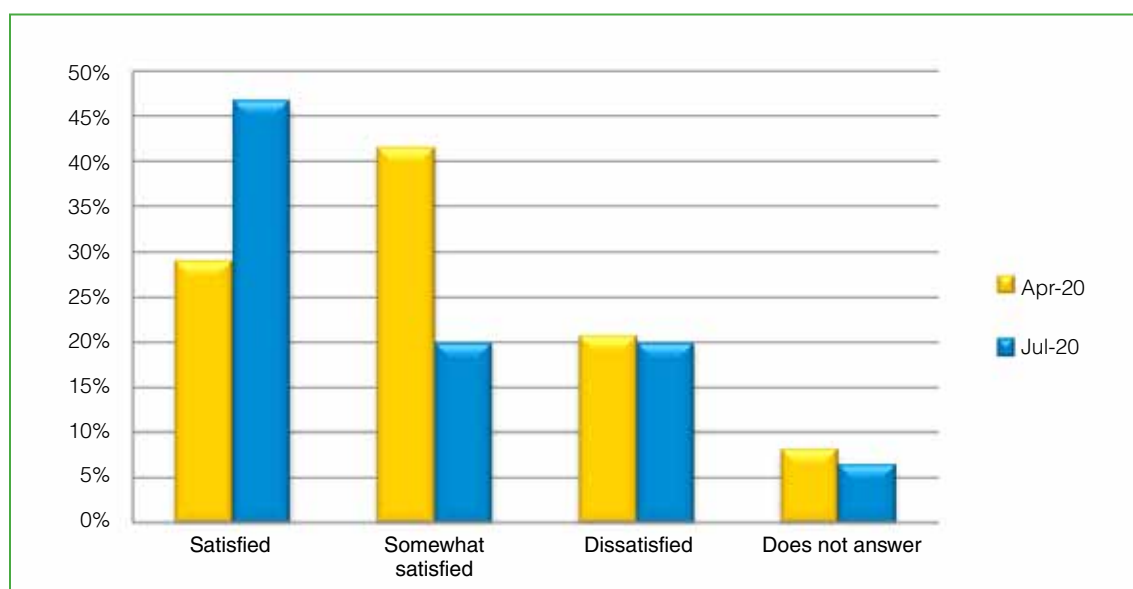


Figure 2. Degree of satisfaction of professionals using telemedicine (April and July 2020).

In April 2022, a new survey was sent to professionals who had answered the two previous surveys. Only three specialists (13%) of respondents in July 2020 continued with telemedicine.

## DISCUSSION

Telemedicine was incorporated into the care of people with diabetic foot when the COVID-19 pandemic restricted access to face-to-face consultation of at-risk patients.<sup>18,19</sup> Some institutions and authors, such as Liu et al., developed protocols of care in times of COVID, still without experimental validation.<sup>20</sup> In this new scenario, we evaluated the use of telemedicine by foot and ankle trauma teams caring for people with diabetic foot in our country.

Although the use of teleconsultation within the framework of a structured health portal is the formal and most systematic way to conduct consultations, in some publications, informal methods of communication between physicians and patients were the most widely used, as they are accessible to many patients or their caregivers.<sup>19,21</sup> Given the need to quickly implement the remote care of many patients in a short time to avoid discontinuing follow-up, a widely used resource was sending photographs in combination with instant messaging applications.<sup>6</sup> However, photo-based diagnosis is not entirely accurate and even the urgency with which access to treatment is stratified differs among different physicians.<sup>22</sup> In our population, the most frequently used tool was images sent by instant messaging, followed by telemedicine platforms in the electronic health record of institutions. We must always take into account the handling of sensitive patient information and safeguard the confidentiality and exposure of data and images, as established in current legislation.<sup>14,15</sup>

Telemedicine also serves to provide self-care advice to patients and their caregivers or nurses, to verify weight-bearing, footwear and healing.<sup>5</sup> This was reflected in our group, where 75% used this tool for prevention. Working collaboratively and remotely is an option at this time to avoid transferring patients to institutions. The foot and ankle specialist can be the first contact the patient has with the health team when consulting them for a new foot injury; therefore, it is vital to maintain this network effectively, through instant communication.<sup>16,17</sup>

Before the pandemic, some authors already advocated the use of telemedicine<sup>9</sup> and reported similar results in diabetic foot care compared to face-to-face care. Care times and costs decreased, and documentation processes improved, while healing times were similar.<sup>23</sup> Moore et al., among others, mention the advantages of this method, particularly in the care of patients in remote or rural regions.<sup>24</sup> Other studies, such as Nordheim et al., point to the lack of evidence for the validation of telemedicine.<sup>25,26</sup> Even a higher mortality rate has been reported for patients in telemedicine follow-up.<sup>24,26,27</sup>

Among the problems related to telemedicine, some authors have highlighted the difficulty of implementing it suddenly without previous experience, the lack of a legal framework for medical practice, and the problems related to the payment of the consultation and its value.<sup>9,26</sup> Other disadvantages are the lack of sufficient validation for the care of people with diabetic foot, the interobserver discrepancy in diagnoses and treatments, and the impossibility of obtaining all the necessary information from the images sent by the patient.<sup>22</sup> The most frequent reason of dissatisfaction with telemedicine in our field was the lack of a physical in-person examination.

While the use of telemedicine through health portals increased in 2020 due to the pandemic, in our field, the resource preferred and used by the majority of the professionals surveyed was telephone conversation, followed by sending images by instant messaging applications. In April 2022, once face-to-face care activity normalized in Argentina, only 13% continued with telemedicine consultations, a similar percentage (15%) to specialists who conducted such consultations before the COVID-19 pandemic; no greater adherence of professionals to this type of consultation was achieved.

Despite the great possibilities and applications of telemedicine, we believe that rigorous project evaluations are needed in this patient group. Firstly, because of the financial sustainability challenges facing health systems and, secondly, because of the lack of sufficient clinical evidence on such projects. Evaluation should therefore be a planned process capable of determining the feasibility of use and its impact. It will be necessary to re-

organize and define which practices will remain routine in the consultation and how the care of patients with diabetic foot will be transformed in the post-pandemic era.<sup>7,19,21,28</sup>

As weaknesses of our study, we can mention that it is a small sample and that the respondents in the second survey are not totally repeated. As strengths, we have not yet found any published studies on the use of telemedicine in trauma teams, not especially in foot and ankle teams in our region, during or before the COVID-19 pandemic.

The results of this survey could be useful as a basis for planning the use of this tool in the usual practice of our specialty.

## CONCLUSIONS

The use of telemedicine by foot and ankle trauma teams in relation to the care of people with diabetic foot in Argentina increased compared to the pre-pandemic era; from 15% to 61.5% during the beginning of 2020. Upon returning to face-to-face care, the rate of adherence to telemedicine returned to 13%.

Only 37.5% of respondents who conducted remote consultations did so through telemedicine platforms. 87.5% used instant messaging for remote consultation. The percentage of specialists who were satisfied or partially satisfied remained stable in both surveys (70.7% and 66.7%, respectively); however, there was a higher percentage of total satisfaction in the second survey (46.7%) compared to the first (29.1%). None of those who were dissatisfied with the tool reported being satisfied in the second instance.

Conflict of interest: The authors declare no conflicts of interest.

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# Diabetic Foot: Mortality Rates After Major Amputation

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## ABSTRACT

**Introduction:** Major amputations cause a high rate of morbidity and mortality. Our objectives were to evaluate the mortality rate in the first month, and 2 and 5 years after amputation for diabetic foot and to compare the mortality rate in patients with below-the-knee (BKA) and above-the-knee amputations (AKA). **Materials and Methods:** Sixty patients with 64 major amputations, operated on between 2010 and 2018, were retrospectively evaluated. The following information was collected: personal data, laterality, University of Texas classification score, biochemical analysis results, Doppler studies, comorbidities, survival, and cause of death. The overall mortality rate and the mortality rate by type of amputation in the first month and after 2 and 5 years were calculated. **Results:** 58 amputations were performed in men and 6 in women (37 right, 27 left), 39 were AKA and 25 were BKA. The average age was 68 years. There were 28 deaths: 15 patients with AKA and 13 with BKA. Mortality rates were: 13.33% in the first month, 33.3% after 2 years, and 46.42% after 5 years (patients with AKA, 26.78%; patients with BKA, 19.64%). The differences in the creatinine levels of the patients who died were statistically significant. The main causes of death were cardiovascular complications. **Conclusions:** Mortality rates were significantly higher in patients with above-the-knee amputation. The sepsis-related mortality rate in the first month was high. Patients with kidney disease had a higher mortality rate.

**Keywords:** diabetic foot, amputation, mortality

**Level of Evidence:** IV

## Pie diabético: tasas de mortalidad en pacientes con amputaciones mayores

## RESUMEN

**Introducción:** Las amputaciones mayores provocan una elevada tasa de morbimortalidad. Los objetivos de este estudio fueron evaluar la tasa de mortalidad al mes, y a los 2 y 5 años de una amputación por pie diabético y comparar la tasa de mortalidad en pacientes con amputación infrarrotuliana o supracondílea. **Materiales y Métodos:** Se evaluó retrospectivamente a 60 pacientes con 64 amputaciones mayores, operados entre 2010 y 2018. Se reunió la siguiente información: datos personales, lateralidad, puntaje de la clasificación de la Universidad de Texas, análisis bioquímicos, estudio Doppler, comorbilidades, supervivencia y causa del óbito. Se calculó la tasa de mortalidad general y por tipo de amputación al mes, a los 2 y 5 años. **Resultados:** Se realizaron 58 amputaciones en hombres y 6, en mujeres (37 derechas, 27 izquierdas), 39 fueron supracondíleas, y 25 infrarrotulianas. La edad promedio era de 68 años. Hubo 28 óbitos: 15 pacientes con amputación supracondílea y 13 con amputación infrarrotuliana. Las tasas de mortalidad fueron: 13,33% al mes; 33,3% a los 2 años y 46,42% a los 5 años (pacientes con amputación supracondílea 26,78%; pacientes con amputación infrarrotuliana 19,64%). Las diferencias en los niveles de creatinina de los pacientes que murieron fueron estadísticamente significativas. Las principales causas de muerte fueron las complicaciones cardiovasculares. **Conclusiones:** Las tasas de mortalidad fueron significativamente superiores en los pacientes con amputación supracondílea. La tasa de mortalidad al mes relacionada con sepsis fue alta. Los enfermos renales tuvieron una tasa de mortalidad mayor.

**Palabras clave:** Pie diabético; amputación; mortalidad.

**Nivel de Evidencia:** IV

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## INTRODUCTION

Major amputations due to diabetic foot are procedures with high morbidity and mortality rates. Awareness of these rates and their related factors is especially important for designing diagnostic and treatment strategies that reduce complications and deaths in these patients. Published studies on this subject differ in their methodology, but report very high mortality rates<sup>1,2</sup> which vary according to the level of amputation.<sup>3</sup> Likewise, the populations studied are diverse and the results are not necessarily applicable to our population.

The objective of this study was to evaluate the mortality rate one month, two, and five years after a major amputation due to diabetic foot. The secondary objectives were to assess the differences in mortality rates between patients with below-knee or above-knee amputations, and to relate them to their possible causes.

## MATERIALS AND METHODS

We retrospectively studied 60 patients with insulin-dependent type 2 diabetes. 64 amputations were performed between January 2010 and January 2018 in a highly complex hospital in the Autonomous City of Buenos Aires. The inclusion criteria were: amputation due to diabetic foot and surgery performed in our hospital, by personnel from the trauma service. The exclusion criteria were: traumatic, primary vascular, or tumor cause, or any other etiology not related to diabetic foot. A form was prepared with detailed information on the patient, including personal data, age, sex, date of surgery, laterality, University of Texas classification score, biochemical analyses at the time of surgery, results of the arterial and venous Doppler study, survival, survival time, and causes of death. Associated comorbidities were also recorded, such as nephropathy, arterial hypertension, dyslipidemia, peripheral vascular disease, and neuropathy. The association of comorbidities between the groups of living and deceased patients was evaluated to analyze if there were statistically significant differences. Serum creatinine values were recorded at the time of surgery, and the difference between the values of the living and deceased patients was analyzed using Student's t-test. The overall mortality rate and the mortality rate by type of amputation were calculated one month, two and five years after the amputation. In addition, we studied whether or not there were statistical differences between the groups with above-knee or below-knee amputations. We devised a value that we define as "mean time to death", which is calculated by averaging the time in years from amputation to death, and we evaluated the comorbidities of each group and those common to both groups.

All amputations were carried out by surgeons from the orthopedics and trauma service. The indication and level of amputation were agreed upon by the institution's diabetic foot committee. All amputations, both BKA and AKA, consisted of dissection by planes, hemostasis, triple arteriovenous ligation of each bundle, nerve phenolization and section under traction, bone cutting with a hand saw, rasping of edges, and closure by planes. The Burgess technique<sup>4</sup> was used for BKAs and the fish-mouth incision<sup>4</sup> for AKAs. The average surgery time was 1.5 and 1 h, respectively. None of the amputations in this study group were performed with the guillotine modality.

## RESULTS

64 amputations were performed on 60 patients (58 on men, 6 on women), 37 were in the right limb and 27 in the left limb. In 39 patients, a supracondylar level of amputation was indicated and, in 25, an infrapatellar level. The average age of the sample was 68 years (range 44-92). The total number of deaths was calculated, taking into account the level of amputation (supracondylar or infrapatellar), in a period of time (one month, two years and five years). There were 28 deaths (Table 1), of which 15 (61%) were in patients with AKA and 13 (39%) were in patients with BKA. Mortality rates are shown in Figure 1.

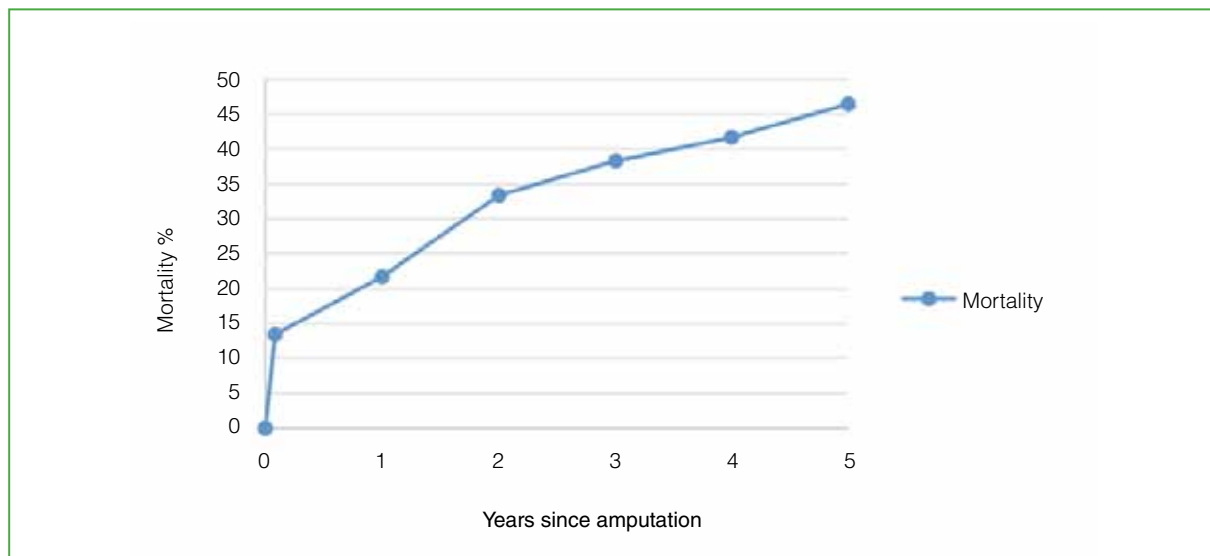
Likewise, the mortality rate was calculated according to the level of amputation and the results are shown in Figure 2. A significant difference was found between the mortality rates of patients with AKA or BKA ( $p \leq 0.03$ ).

The average overall time until death was 1.7 years, the average time until death was also calculated in patients with supracondylar (1.27 years) and infrapatellar (2.19 years) amputations.

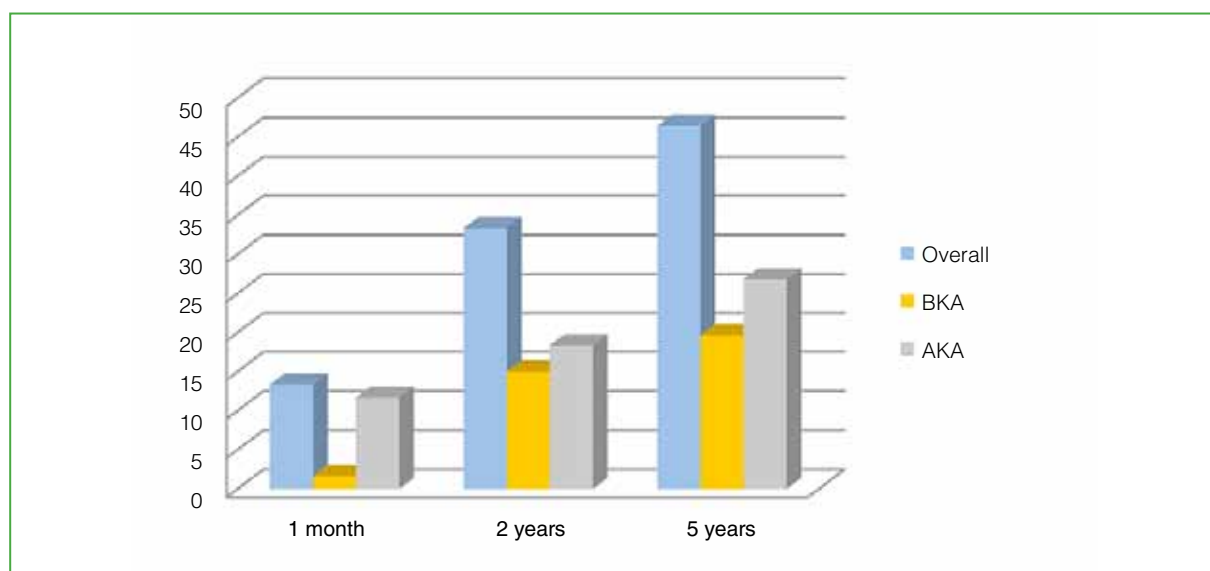
Serum creatinine levels were compared between living and deceased patients, and a statistically significant difference ( $p \leq 0.02$ ) was obtained, with an average of 1.05 mg/dl in the living and 2.5 mg/dl in the deceased. The causes of death are detailed in Table 2.

**Table 1.** Mortality rate and number of deaths one month, two years and five years after amputation

	Mortality rate			Deaths		
	After one month	After 2 years	After 5 years	After one month	After 2 years	After 5 years
Overall	13.33	33.34	46.43	8	20	26
Below-knee amputation	1.67	15	19.64	1	9	11
Above-knee amputation	11.67	18.34	26.79	7	11	15



**Figure 1.** Mortality rate as a function of time since amputation.



**Figure 2.** Comparative graph of the general mortality rate and by type of amputation, one month, 2 and 5 years after a major amputation.

**Table 2.** Quantity and causes of death

Deaths/ Cause	Diabetes	Septic complication	Vascular	Community-acquired acute pneumonia	Acute myocardial infarction	Unknown	Other
28	5	4	3	5	5	4	2
100%	17.86%	14.29%	10.71%	17.86%	17.86%	14.29%	7.14%

## DISCUSSION

Approximately 20% of diabetic patients will develop an ulcer at some point in their lives, and 20% of these will require a major amputation. It is estimated that an amputation is performed every 30 seconds in the world<sup>5</sup> and, according to data from the World Health Organization, more and more people suffer from diabetes, so it is necessary to know, in detail, the evolution in the short and long term of each therapeutic treatment.

Amputation is reserved for those feet that are non-viable or infected by germs whose resistance makes them untreatable.

Most research studies on diabetic foot address issues of ulcer prevention and treatment.<sup>2</sup> Different studies have reported the mortality rate after a major amputation,<sup>2</sup> but we did not find national publications on the matter. The comorbidities studied and the study methodology differ, and the surgical techniques used are not mentioned, all of which make it difficult to compare the results and raise the need to carry out more detailed investigations. Published mortality rates are high, but differ from one another. Some authors, such as Hoffman et al., reported that the prognosis of patients amputated due to diabetic foot is comparable to that of those with malignant diseases,<sup>1,2</sup> and the five-year mortality rate is only surpassed by that of lung cancer.<sup>1</sup>

According to Jupiter et al., five years after the appearance of the ulcer, the mortality rate reaches 40%,<sup>3</sup> so a higher value is to be expected for amputees, as occurs in our sample with a five-year rate of 46.4%.

The authors who address the subject of deaths usually do so after a month, and after 1, 2 and 5 years.

In a review study based on data from 31 publications, mortality rates of 53% to 100% at five years, 40-82% after below-knee amputation, and 40-90% after above-knee amputation were reported,<sup>6</sup> which shows a high overall mortality rate, higher than that obtained in our study (46.4%).

These authors found differences between mortality rates according to the type of amputation, which also occurred in our sample, with values of 19.6% and 26.7% in patients with below-knee and above-knee amputations, respectively.

In a review, Stern<sup>12</sup> found mortality rates of 47.9%; 61.3%; 70.6%, and 62.2% after one, two, three, and five years of follow-up, respectively, which are very high compared to our results and could be due to cardiovascular events, as the authors conclude.

Schofield et al. established that the mortality rate is 55% higher in diabetic amputees than in non-diabetics and that they have a higher risk of suffering cardiovascular events and new amputations.<sup>7</sup> Although this point was not the subject of our analysis, it shows a particularly high mortality rate in diabetic patients.

Soo et al.<sup>8</sup> reported a mortality rate of 60% at five years and 75% at 10 years, highlighting age >70 years as a poor prognostic parameter; in our study, it was not possible to assess it, because the majority belonged to that age group (mean age 68).

The mortality rate after the first month is also recorded as high,<sup>7</sup> ranging between 8% and 25%, and is related to the supracondylar or infrapatellar level (17.5% and 4.2%, respectively).<sup>9</sup>

In our series, the 1-month mortality rate was 13.3% (1.6% in patients with supracondylar amputation and 1.6% in those with infrapatellar amputation).

## Causes of death

The causes of death are difficult to assess due to the loss of follow-up.<sup>8,9</sup> Despite this, it is known that cardiovascular events are the first cause.<sup>10</sup> Amputees with diabetes are twice as likely to die from heart failure than non-diabetics,<sup>7</sup> and have a 55% higher mortality rate. The level of amputation also influences the risk of suffering heart attacks, it is higher if the amputation is above the knee,<sup>9</sup> with risk rates of perioperative cardiovascular events of 6.8% and 3.6% for amputations above and below the knee, respectively.<sup>9</sup> Heart failure in diabetic patients is more prevalent and even more serious if it is secondary to a heart attack.<sup>2,7</sup>

In our series, the predominant cause of death was acute myocardial infarction (17.86%) which, despite being an important cause according to the literature, did not have a strong incidence as a separate entity in our sample, but was associated with peripheral vascular diseases (10.71%), adding 28.57% of the causes of death as global cardiovascular complications.

The metabolic complications of diabetes (17.86%) and pneumonia (17.86%) also appear among the main causes of death, followed by sepsis, which represented 14.29% of deaths, mainly in the first month post amputation.

## Risk factors

There are risk factors that predispose to a higher mortality rate, such as age, peripheral vascular disease, kidney disease, and previous amputation.<sup>6,8,11</sup> In our series, it was not possible to analyze peripheral arterial disease, dyslipidemia, and age as independent risk factors, because almost all patients had these characteristics, to different degrees, not always specified in the medical records, so it is an aspect to be addressed in the future and prospectively.

Stern et al. mentioned that, in addition to diabetes and peripheral arterial disease, other factors, such as coronary artery disease, stroke, kidney disease, ASA 4, and dementia double the risk of death.<sup>12</sup>

Renal failure, on the other hand, was not a constant and creatinine values showed statistically significant differences between patients who died within five years and those who survived, who had lower values. Renal failure is not always described as a risk factor in the literature,<sup>6</sup> and, in light of our results, it should at least be taken into account. Regarding the cut-off value to consider kidney damage, Davenport et al. take as a parameter a serum creatinine value  $\geq 1.2$  mg/dl or the need for dialysis.<sup>13</sup>

Above-knee amputation is a factor associated with a higher mortality rate,<sup>9</sup> which is consistent with our results.

Prolonged hospitalization was reported as a risk factor for death in the first month; it has been reported that when it occurs between 9 and 12 days, it is due to comorbidities and their management.<sup>12</sup>

## CONCLUSIONS

In the series studied, the mortality rates were: 13.33% in the first month, 33.3% after two years, and 46.42% after five years. Mortality rates in patients with supracondylar amputation were significantly higher than in those with infrapatellar amputation, in all periods analyzed. The high mortality rate in the first month (13.33%) is mainly related to sepsis.

Patients with kidney disease had a higher mortality rate, so it is recommended to create a protocol for the study and prevention of said disease.

The main cause of death was cardiovascular complications.

Diabetic patients undergoing a major amputation have a higher mortality rate than those with ulcers, so it is suggested to prevent diabetic foot ulcers and implement limb salvage protocols.

Studies on this subject are methodologically heterogeneous; it is difficult to compare them and establish the causes of their high but disparate mortality rates, so prospective trials should be carried out that also analyze hospitalization times, surgical delays, techniques used, and the suitability of the surgeons.

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# Analysis of Demographic Characteristics in a Series of 94 Patients with Articular Calcaneal Fractures

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## ABSTRACT

**Objective:** To analyze the demographic characteristics of patients with articular calcaneal fractures in connection with trauma mechanisms and fracture patterns, according to the Sanders and Essex-Lopresti classifications. **Materials and Methods:** 94 patients and 111 articular calcaneal fractures were evaluated retrospectively, analyzing the following variables: age, gender, fractured side, mechanism of trauma, and associated injuries. The patients were initially evaluated through foot radiographs (anteroposterior and lateral) and axial computerized tomography with multiplanar reconstruction. Demographic data were analyzed combined with the types of fracture. **Results:** 94 patients (78 men and 16 women) who presented 105 intra-articular calcaneal fractures (11.7% were bilateral) were evaluated. The average age was  $40.1 \pm 12.5$  years. 9.8% of the fractures were caused by high-level falls and 20.1% by traffic accidents. 9.5% had associated injuries. The patients with bilateral fractures presented more associated injuries ( $p = 0.0123$ ) and the same fracture pattern and Sanders type in both feet. The Sanders classification and Essex-Lopresti patterns were unrelated to age, gender, and trauma mechanism. **Conclusion:** Calcaneal fractures are more frequent in male and young patients, and the most common trauma mechanism is a high-level fall. Patients with bilateral fractures present a higher rate of associated injuries and the same Sanders type fracture and Essex-Lopresti pattern in both feet.

**Keywords:** Calcaneal fractures, intra-articular, demographic features, epidemiology

**Level of Evidence:** IV

## Análisis de las características demográficas de 94 pacientes con fracturas articulares de calcáneo

## RESUMEN

**Objetivo:** Analizar las características demográficas de los pacientes con fracturas articulares de calcáneo en relación con el mecanismo del trauma y los patrones fracturarios según las clasificaciones de Sanders y Essex-Lopresti. **Materiales y Métodos:** Se evaluó retrospectivamente a 94 pacientes (111 fracturas articulares de calcáneo). Se analizaron las siguientes variables: edad, sexo, lado fracturado, mecanismo del trauma y lesiones asociadas. Al ingresar, se tomaron radiografías de pie, de frente y de perfil, y se realizó una tomografía computarizada con reconstrucción multiplanar. Se analizaron los datos demográficos combinándolos con los tipos de fracturas. **Resultados:** Se evaluó a 94 pacientes (78 hombres y 16 mujeres) que tenían 105 fracturas intrarticulares de calcáneo (11,7% bilaterales). La edad promedio era de  $40.1 \pm 12.5$  años. El 79,8% de las fracturas se había producido por caída de altura y el 20,1%, por accidente de tránsito. El 9,5% tenía lesiones asociadas. Los pacientes con fracturas bilaterales tenían más lesiones asociadas ( $p = 0,0123$ ) y el mismo patrón fracturario y tipo de Sanders en ambos pies. No hubo relación entre la clasificación de Sanders y los patrones de Essex-Lopresti con la edad, el sexo y el mecanismo del trauma. **Conclusiones:** Las fracturas de calcáneo son más frecuentes en hombres y en pacientes jóvenes, y el mecanismo del trauma más común es una caída de altura. Los pacientes con fracturas bilaterales tienen una tasa más alta de lesiones asociadas y el mismo tipo de fractura según la clasificación de Sanders y el patrón fracturario de Essex-Lopresti en ambos pies.

**Palabras clave:** Fractura de calcáneo; intrarticulares; características demográficas; epidemiología.

**Nivel de Evidencia:** IV

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## INTRODUCTION

Calcaneus fractures represent less than 2% of all fractures, although they are the most frequent tarsus injury.<sup>1</sup> These fractures usually occur in workspaces, the most common trauma mechanism being height falls, and in many cases produce sequelae with different kinds of disabilities. As a result, they cause considerable economic losses which are out of proportion with the low prevalence of said injury.<sup>2</sup> Most studies focus on the various treatments and fundamentally on surgical techniques,<sup>3,4</sup> but there are few publications on its epidemiology and the demographic characteristics of patients with calcaneus fractures.<sup>5-8</sup>

The aim of this study was to analyze the demographic characteristics in a series of 94 patients with intra-articular calcaneus fractures, assessing their relation to the trauma mechanism, the fracture patterns according to Essex-Lopresti, and the Sanders classification.

## MATERIALS AND METHODS

We retrospectively evaluated 100 patients with calcaneal joint fractures (111) who were treated at our Service between January 2010 and December 2020. Upon admission, anteroposterior and lateral radiographs of the foot were taken. In the lateral image, the beam was centered on the medial malleolus; in the anteroposterior image, on the medial cuneiform. The beam was parallel in the lateral image, and inclined 15° in the inferior apical direction in the anteroposterior image. The distance from the tube to the cassette was 120 cm in both projections. Before surgery, a multiplanar computerized tomography was performed with slices <1 mm, in the axial, sagittal and semi-coronal planes (30° angle), and 3D reconstruction was used.

Six patients with unilateral fractures who had not been fully evaluated upon admission were excluded. The demographic data analyzed were: age, sex, fractured side, trauma mechanism, and associated injuries. The Sanders classification was used<sup>3</sup> and the fracture patterns were evaluated as “tongue” or “joint depression”, following Essex-Lopresti<sup>9</sup>. The statistical analysis was carried out through descriptive measures (mean and standard deviation, maximum and minimum). The data were loaded into the EPIDAT version 4.2 system. A p-value <0.05 was considered significant.

## FINDINGS

### Age and sex

94 patients (78 men and 16 women) with 105 intra-articular calcaneus fractures were evaluated. The average age was  $40.1 \pm 12.5$  years (range 18-65). The average age for women was  $40.44 \pm 13.59$  (range 19-57), and for men,  $40 \pm 12.33$  (range 18-65).

### Age and unilateral or bilateral fractures

Eighty-three patients (89.3%) had unilateral fractures (46 right and 37 left) and the average age was  $41 \pm 13$  years (range 18-65). Eleven (11.70%) had bilateral fractures and the average age was  $35 \pm 10$  years (range 19-55). The right side was predominant (55.4%). There was no difference between the age of men and women, nor between age, and unilateral and bilateral fractures.

### Trauma mechanism, sex, and unilateral or bilateral fractures

The trauma mechanism was a fall from height in 79.8% of cases and traffic accidents in the rest. All patients with bilateral fractures had suffered a height fall. 77.10% of unilateral fractures were due to this mechanism, and the rest were due to traffic accidents (Figure 1).

Figure 2 shows trauma mechanisms according to sex. There were no statistically relevant differences between the trauma mechanism and the patient's sex, and between unilateral or bilateral fractures, although bilateral fractures were caused by height falls.

### Associated injuries

Nine patients (9.5%) had associated injuries (27% with bilateral fractures and 7.2% with unilateral fractures). Patients with bilateral fractures presented more associated injuries ( $p = 0.0123$ ).

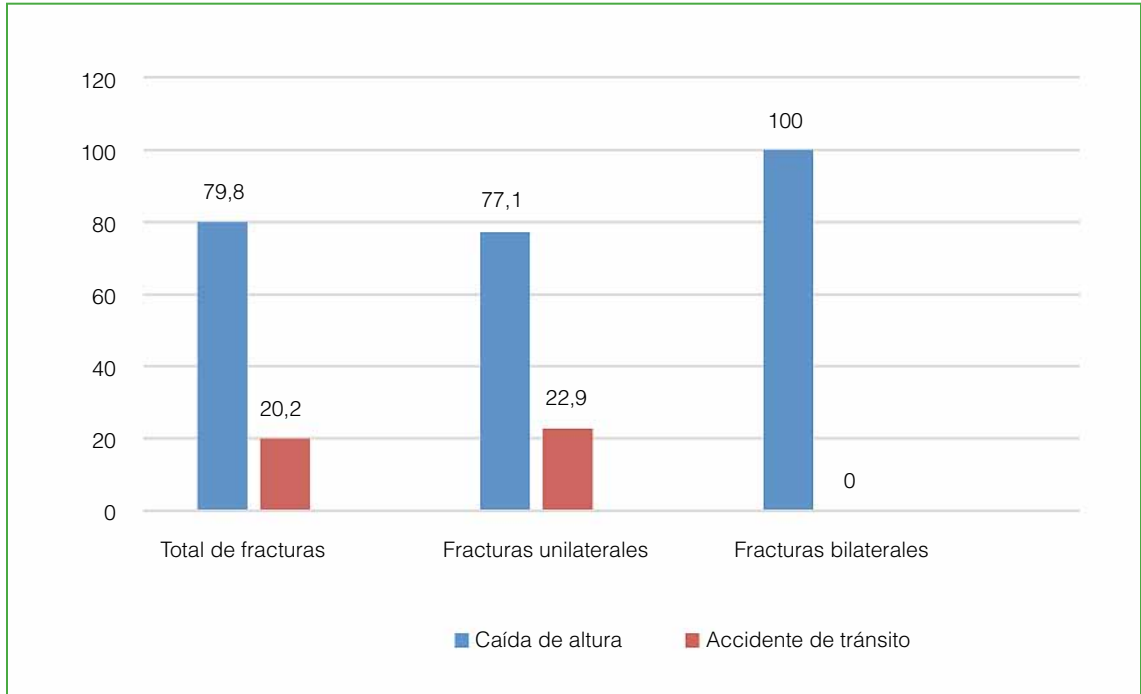


Figure 1. Trauma mechanism for unilateral and bilateral fractures, in all fractures.

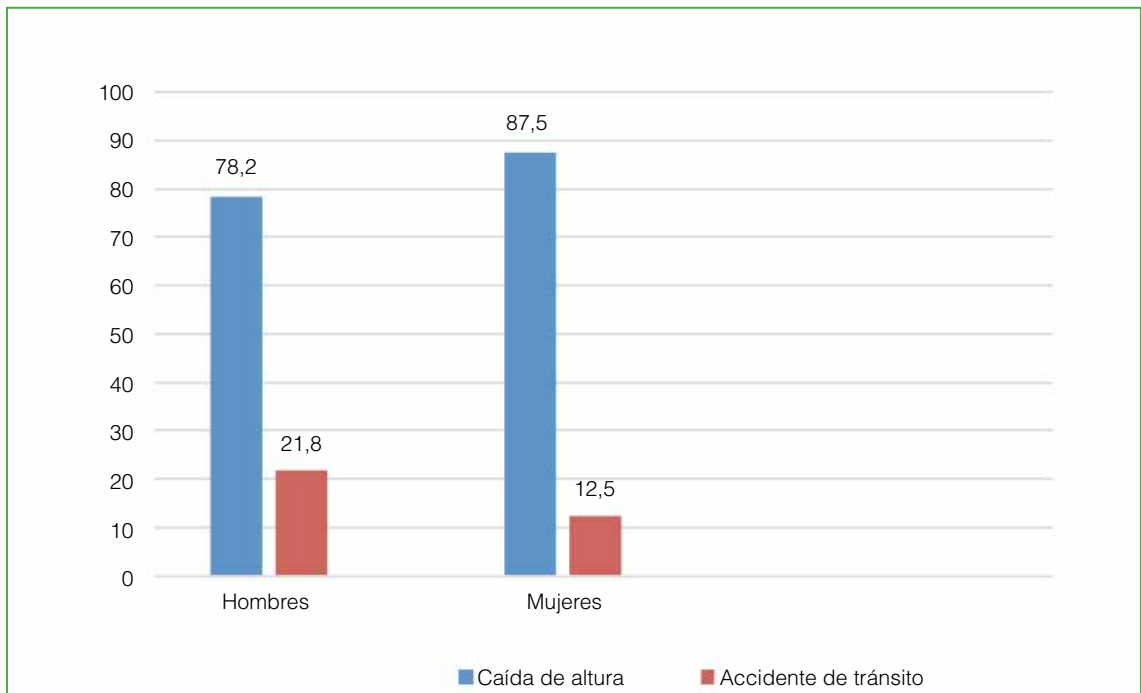
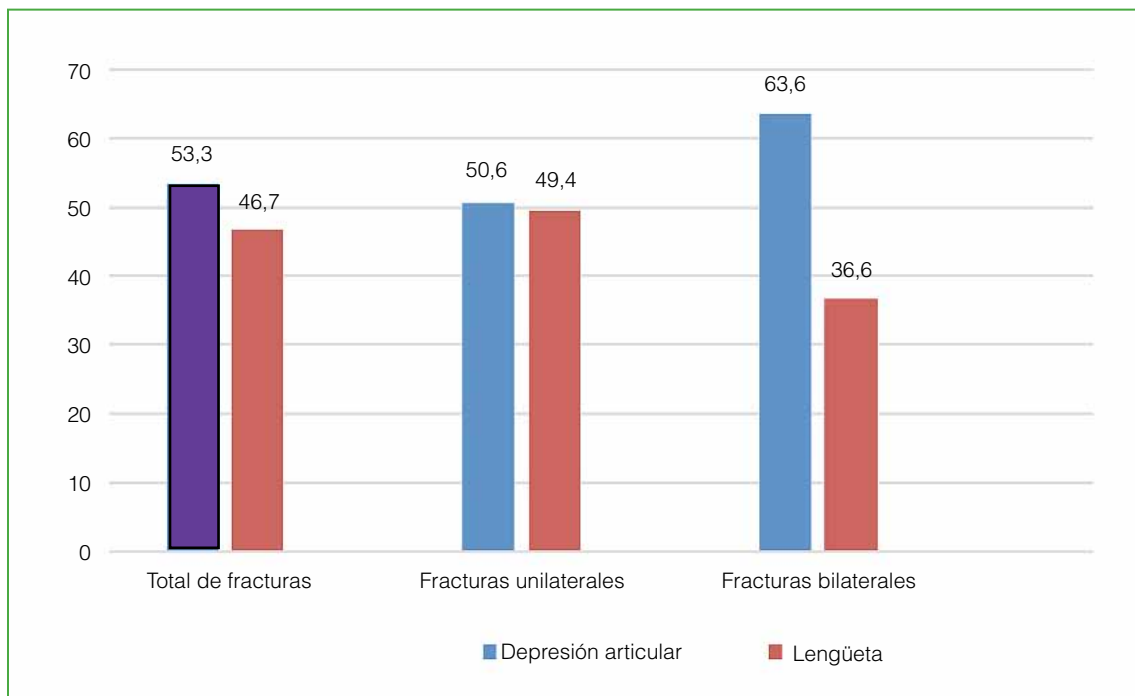


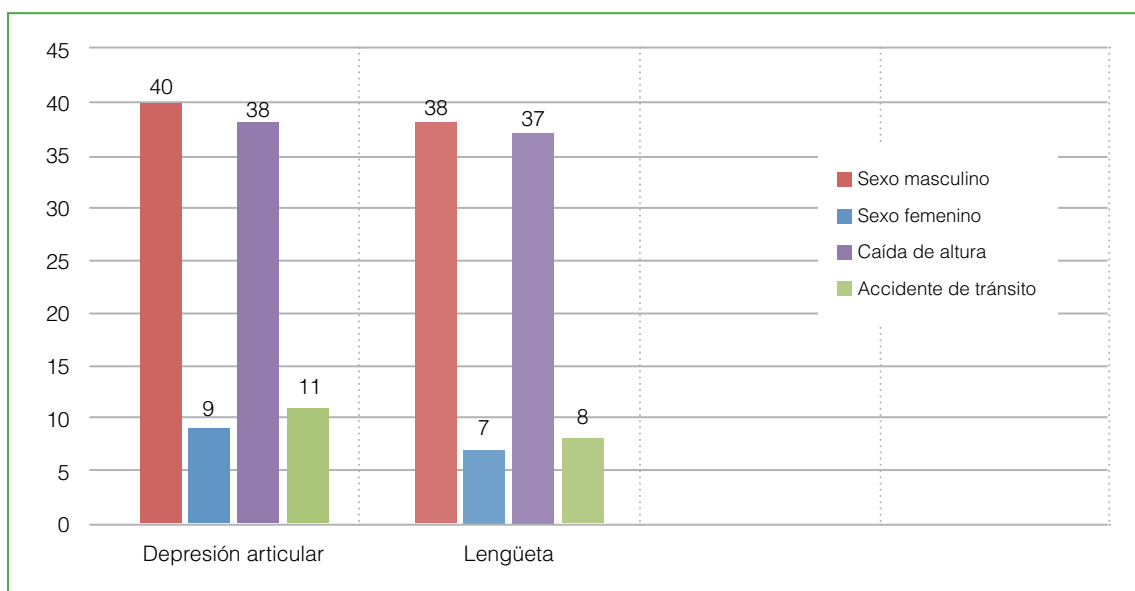
Figure 2. Trauma mechanisms according to sex.

### Essex-Lopresti fracture pattern

53.3% of fractures (56 cases) corresponded to the Essex-Lopresti “joint depression” type. 63.6% were bilateral and 50.6% were unilateral. The rest (47.7%) was classified as “tongue” (49.4% unilateral and 36.4% bilateral). Bilateral fractures had the same fracture pattern in both feet, seven of the “joint depression” and four of the “tongue” type. The age of patients with the “joint depression” fracture type was  $40.67 \pm 13.10$  years; for “tongue” fracture patients, it was  $40.04 \pm 12.41$  years. 81% of patients with “joint depression” fractures were men, and 84% of patients with “tongue” fractures were men. There was no difference between Essex-Lopresti fracture pattern, and age, sex and trauma mechanism (Figures 3 and 4).



**Figure 3.** Distribution according to Essex-Lopresti fracture pattern into unilateral, bilateral, and total fractures.



**Figure 4.** Essex-Lopresti fracture pattern according to trauma mechanism and sex.

### Sanders classification

Regarding the Sanders classification, 66 unilateral fractures were type II (79.5%); 15, type III (18%); and two, type IV (2.4%). The subtype IIA was the most frequent (63%). As regards bilateral fractures, 18 (82%) were type II and four, type III (18%); subtype IIA was the most frequent (50%). Bilateral fractures shared the same Sanders type in both feet. Nine patients were observed to have Sanders type II fractures, and two were type III. The Sanders types were fully matching, but not in every subtype: only in subtypes IIC and IIAB. 80% of type II, 82% of type III, and 100% of type IV fractures corresponded to men. The average age of patients with type II fractures was  $39.7 \pm 11.8$  years; for those with type III, it was  $42.9 \pm 13.8$  years; and for those with type IV,  $44.5 \pm 28.9$ . There was no link between Sanders classification, and age, sex and trauma mechanism (Figure 5).

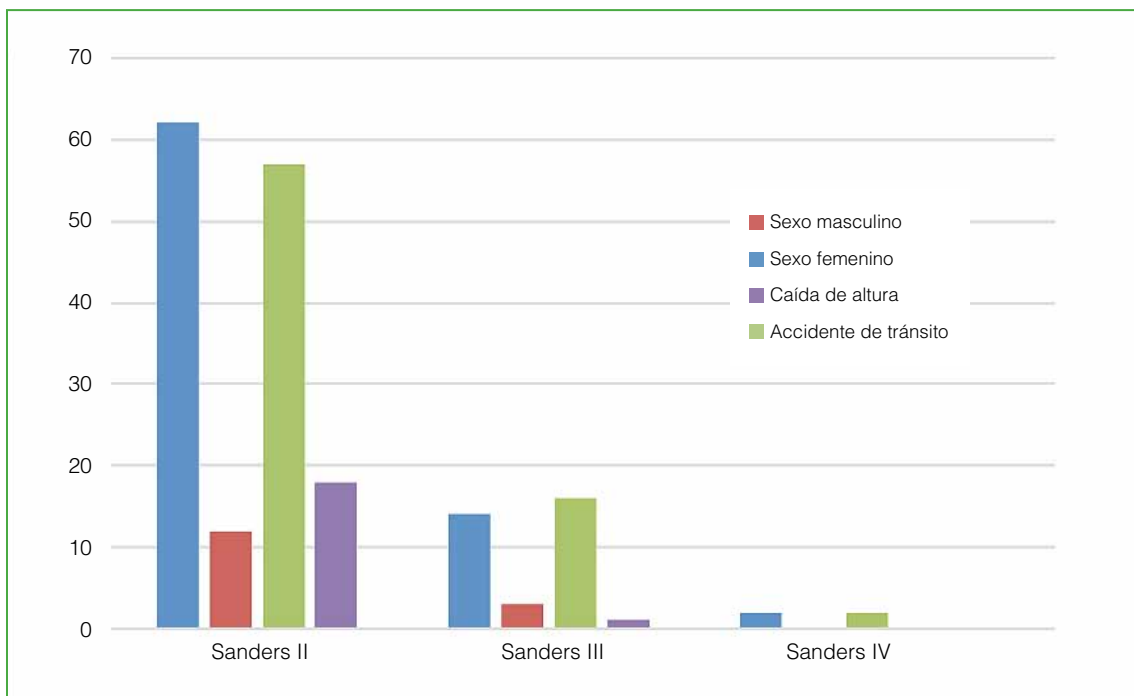


Figure 5. Sanders classification distribution according to trauma mechanism and sex.

## DISCUSSION

Calcaneus fractures account for 2% of all fractures and most occur in adults. The treatment is still controversial, as similar results have been published for conservative and surgical management.<sup>10,11</sup>

The analysis of our series shows that most patients are men (82%) and, according to the literature, this injury occurs more commonly in workspaces.<sup>8</sup> The average age of the patients was  $40.1 \pm 12.5$  years, with no statistically relevant differences between both sexes, a similar figure to those previously published.<sup>6,7</sup>

In these fractures, bilaterality was 7-13%.<sup>2,12</sup> Although there are no demographic differences between patients with unilateral and bilateral fractures, the latter could be more prevalent among younger adults.<sup>3</sup> In our series, all of them were caused by height falls in workspaces, predominantly on men (63%). These account for 11.7% of the entire series.

The two most common trauma mechanisms are height falls and traffic accidents.<sup>6-8</sup> In Atkins's series, height falls amounted to 91%. In our analysis, we observed that 79.8% of unilateral and all bilateral fractures owed to height falls. The trauma mechanism was similar for both sexes.

According to the different publications, the presence of associated injuries is very variable. Bohl *et al.*<sup>8</sup> communicate a 77% of associated injuries; Mitchell *et al.*,<sup>6</sup> a 22%; and Benson *et al.*,<sup>7</sup> a 93%. In our series, 9.5% had associated injuries. In bilateral fractures, the rate of associated injuries was higher (27%) than in unilateral fractures. This is explained by higher-energy traumas.

When the fracture pattern was analyzed based on Essex-Lopresti,<sup>9</sup> a similar distribution was observed in all fractures, of both the “tongue” and “joint depression” types. In bilateral fractures, the predominant fracture pattern was the “joint depression” type (63.6%). No correlation between this classification, and age, trauma mechanism and sex was found. We did observe that bilateral fractures presented the same fracture pattern in both feet.

A prevalence of Sanders type II fractures was detected in both unilateral (79.5%) and bilateral (82%) cases, while type III fractures amounted to 18% in both. Bilateral fractures shared the same Sanders type in both feet, but not the same subtype. No correlation between this classification, and age, trauma mechanism and sex was found.

One of the limitations of this series is its retrospective design, but the number of patients is significant.

## CONCLUSIONS

The analysis of our series allows us to conclude that calcaneus fractures are more frequent in males and young patients, and that the most common trauma mechanism is a height fall. In patients with bilateral fractures, the rate of associated injuries is higher, and the type of fracture is the same in both feet, according to the Sanders classification and the Essex-Lopresti fracture pattern.

Conflict of interest: The authors declare no conflicts of interest.

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# Sinus Tarsi Approach for the Treatment of Calcaneus Fractures: an Increasingly Used Technique

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## ABSTRACT

**Objective:** To describe functional and radiographic outcomes, and complications of osteosynthesis in calcaneus fractures with the sinus tarsi approach. **Materials and Methods:** 54 displaced articular calcaneus fractures in 50 patients were assessed through preoperative foot radiographs (anteroposterior and lateral) and computerized tomography. AP and lateral radiographs were obtained in the immediate postoperative period (without weightbearing), after 6 and 12 weeks (with weightbearing), and at the end of follow-up, measuring the Böhler angle and quantifying the degree of subtalar and calcaneocuboid osteoarthritis. The AOFAS score was determined, registering wound complications, neurological injuries and necessary additional surgeries—such as osteosynthesis and subtalar arthrodesis hardware removal. **Results:** Follow-up time was 30.8 months. The series consisted in 8 women and 42 men. The patients' average age was  $39.40 \pm 14$  years (18-65). There were 40 Sanders type II, 13 type III, and 1 type IV fractures. The AOFAS score was excellent (12 patients), good (25), regular (12), and poor (5). The Böhler angle was  $10.8^\circ \pm 10.4^\circ$  before surgery, and  $30.77^\circ \pm 8.24^\circ$  at the end of follow-up ( $p < 0.00001$ ). 3.7% of the patients presented minor wound complications, while 5.6% presented major wound complications. **Conclusion:** The sinus tarsi approach allows for acceptable reduction with good and excellent outcomes in most patients, coupled with few soft-tissue complications.

**Keywords:** calcaneus, mini-invasive approach, sinus tarsi, fractures, complications

**Level of Evidence:** IV

## Abordaje del seno del tarso para el tratamiento de las fracturas de calcáneo: una técnica de creciente difusión

## RESUMEN

**Objetivo:** Describir los resultados radiográficos y funcionales, y las complicaciones de la osteosíntesis de fracturas de calcáneo mediante el abordaje del seno del tarso. **Materiales y Métodos:** Se evaluaron 54 fracturas articulares de calcáneo desplazadas en 50 pacientes con radiografías de pie, de frente y de perfil, y tomografía computarizada preoperatorias. Se tomaron radiografías de pie, de frente y de perfil sin carga en el posoperatorio inmediato y con carga a las semanas 6 y 12, y al final del seguimiento. Se midió el ángulo de Böhler y se cuantificó el grado de artrosis subastragalina y calcaneocuboidea. Se determinó el puntaje de la AOFAS y se registraron las complicaciones de la herida, las lesiones neurológicas y la necesidad de cirugías adicionales, como retiro del material de osteosíntesis y artrodesis subastragalina. **Resultados:** El seguimiento fue de 30.8 meses. La serie estaba formada por 8 mujeres y 42 hombres, con una edad de  $39.40 \pm 14$  años (rango 18-65). Cuarenta fracturas eran Sanders tipo II, 13 tipo III y 1 tipo IV. El puntaje de la AOFAS fue: excelente (12 casos), bueno (25 casos), regular (12 casos) y malo (5 casos). El ángulo de Böhler preoperatorio era de  $10,8 \pm 10,4^\circ$  y  $30,77 \pm 8,24^\circ$  al final del seguimiento ( $p < 0,00001$ ). El 3,7% tuvo complicaciones menores de la herida y el 5,6%, complicaciones mayores. **Conclusión:** El abordaje del seno del tarso permite una reducción aceptable con resultados buenos y excelentes en la mayoría de los pacientes y escasas complicaciones de partes blandas.

**Palabras clave:** Calcáneo; abordaje mininvasivo; seno del tarso; fractura; complicaciones.

**Nivel de Evidencia:** IV

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## INTRODUCTION

Calcaneus fractures represent 60% of traumatic foot injuries in adults and 2% of total fractures.<sup>1</sup> The treatment of displaced calcaneal joint fractures is still controversial, although open reduction and osteosynthesis through the extended lateral approach (ELA) have been the reference pattern in the last three decades.<sup>2,3</sup>

The high rate of published complications<sup>4,5</sup> has led to the development of less invasive surgeries<sup>6,7</sup> to reduce soft tissue trauma and the risk of complications, with acceptable success.

The minimally invasive sinus tarsi approach allows for adequate visualization and reduction of the fracture, reducing the rate of complications.<sup>8</sup>

The aim of our research was to describe the radiographic and functional outcomes, as well as the complications, of calcaneus fracture osteosynthesis through the sinus tarsi approach.

## MATERIALS AND METHODS

Our retrospective analysis comprised 54 displaced calcaneal joint fractures in 50 patients, treated with osteosynthesis through the sinus tarsi approach between 2011 and 2018. The exclusion criteria were ipsilateral ankle and foot fractures, growing-age patients, >65 years, follow-up <12 months, previous surgeries on the same foot or ankle, and fractures with more than 30 days of evolution. The surgical criteria were Böhler angle <20°, joint incongruity >2 mm, varus >5°, valgus >10°, width ≥5 mm, and gap >3 mm.

The fractures were classified according to Sanders<sup>4</sup> and Essex-Lopresti. The exposed fractures were treated with a surgical mechanical toilet plus intravenous antibiotics, according to Gustilo's classification.<sup>9</sup>

### Radiographic evaluation

The patients were evaluated before surgery with anteroposterior and lateral foot radiographs. The radiation in the lateral and anteroposterior projections was 4 mA, 60 kV, 3,2 mA, and 57 kV, respectively. In the lateral projection, the ray was centered on the medial malleolus;

in the anteroposterior projection, on the medial cuneiform. The ray was parallel to the ground in the lateral radiograph and inclined 15° in the caudocranial direction in the anteroposterior. The distance from the tube to the cassette was 120 cm in both projections. Before surgery, a CT scan with multiplanar reconstruction was performed.

Anteroposterior and lateral foot radiographs were taken without weight-bearing in the immediate postoperative period, and with weight-bearing at weeks 6 and 12, and at the end of follow-up.

On the lateral radiograph, the Böhler angle was measured, consisting of two lines, one from the highest point of the anterior tuberosity to the highest point of the posterior facet, and the other, tangential to the superior border of the posterior tuberosity. Their value ranges from 20° to 40°.<sup>10</sup> It was quantified if there were changes >5° that indicate a collapse of the calcaneal height.<sup>7</sup> The degree of osteoarthritis in the subtalar and calcaneocuboid joints was evaluated.<sup>11</sup> The CT scan was taken to detect any involvement of the calcaneocuboid joint.

### Clinical evaluation

A functional evaluation was conducted using the AOFAS (American Orthopaedic Foot and Ankle Society) scale. The result was classified as: excellent >90, good >80, fair >70 and poor ≤70.<sup>12</sup>

Subtalar range of motion was evaluated comparatively. Wound complications were recorded and divided into minor (edge necrosis, superficial dehiscence) and major (deep infection or dehiscence, and osteomyelitis).<sup>13</sup> Neurological injury and the need for additional surgeries were also evaluated, such as the removal of osteosynthesis material and subtalar arthrodesis.

The statistical analysis was carried out through descriptive measures (mean and standard deviation, maximum and minimum). The data were loaded into the Epidat 4.2 system, considering a p-value <0.05 as statistically significant.

### Surgical technique

The patient is placed in the lateral decubitus position and a 3-5 cm approach is performed on the sinus tarsi, 1 cm distal to the fibula up to the fourth metatarsal (Figure 1).

The peroneals are retracted posteriorly, proceeding to capsular opening to observe the subtalar joint, the anterior tuberosity, and the lateral wall (Figure 2).



**Figure 1.** Marking of the sinus tarsi approach.



**Figure 2.** Facet joint and anterior process of the calcaneus.

One distractor with a 5 mm cancellous Schantz or a Kirschner pin of the same diameter is placed on the posterior tuberosity, and a second one is placed on the lateral part of the talus —to recover height— or on the cuboid —to restore length— (Figure 3).



**Figure 3.** Placing of Kirschner pins on the posterior tuberosity and the lateral part of the talus, and mounting of the distractor on them.

If necessary, the medial fragment is reduced by direct incision. Afterward, the posterior tuberosity is aligned percutaneously with the distractor's Schantz or Kirschner and fixed with a needle to the medial segment. Then, the superolateral fragment is stabilized to the medial fragment before disimpacting and elevating it, in Sanders type II cases. In Sanders III or IV fractures, the intermediate fragments are reduced and then fixed with Kirschner pins (Figure 4).



**Figure 4.** Broden view. The stabilization of the posterior tuberosity toward the sustentaculum tali, using a screw and pin, plus the reduction of the superolateral fragment towards the sustentaculum tali, can be observed.

The talus's lower surface is used as a mold. 6.5 mm full-thread or partially threaded screws and 3.5 mm cortical screws without compression are placed from the posterior tuberosity up to the medial fragment; 3.5 mm screws are used from the superolateral to the medial fragment (Figure 5).



**Figure 5.** **A.** Lateral foot radiograph. “Joint depression” fracture pattern. **B.** Anteroposterior foot radiograph. **C.** Computerized tomography of the foot, coronal plane. Sanders IIIAB. **D.** Computerized tomography, axial plane. **E.** Computerized tomography, sagittal plane. **F.** Intraoperative lateral image of the foot with intensification, osteosynthesis control. **G.** Intraoperative image with Broden view. Reduction of the facet joint. **H.** Lateral radiograph of the foot with weight-bearing, one year after surgery. Adequate reduction of subtalar and Böhler angle. **I.** Anteroposterior radiograph of the foot with weight-bearing, one year after surgery.

From the posterior tuberosity to the anterior process, 6.5 mm or 3.5 mm screws are used. One or two additional screws may be necessary from the upper edge of the superolateral to the plantar fragment for the “tongue-type” fracture pattern (Figure 6).



**Figure 6.** **A.** Lateral foot radiograph. “Tongue” fracture pattern. **B.** Computerized tomography of the foot, sagittal plane. **C.** Computerized tomography, coronal plane. Sanders II A. **D.** Lateral foot radiograph, one year after surgery. Adequate Böhlér angle. **E.** Anteroposterior foot radiograph, one year after surgery.

2.7 mm or 3.5 mm locking plates are placed from the joint surface to the anterior tuberosity (Figure 7).

An intraoperative Broden view of the calcaneus with image intensifier was used to verify the reduction of the posterior facet and to assess the existence of joint gap or step-off (Figure 8).<sup>14</sup>



**Figure 7.** Image of the anatomical reduction of the calcaneus's facet joint and mounting with a 3.5 mm locking titanium plate, solidifying the joint surface and the anterior tuberosity.



**Figure 8.** Intraoperative Broden view with acceptable reduction of the subtalar joint.

In the postoperative period, a posterior splint is placed for 10 days, and ankle and subtalar range of motion is initiated. Partial weight-bearing with crutches and a splint starts at week 4 and progresses until weeks 10-12, when weight-bearing is total.

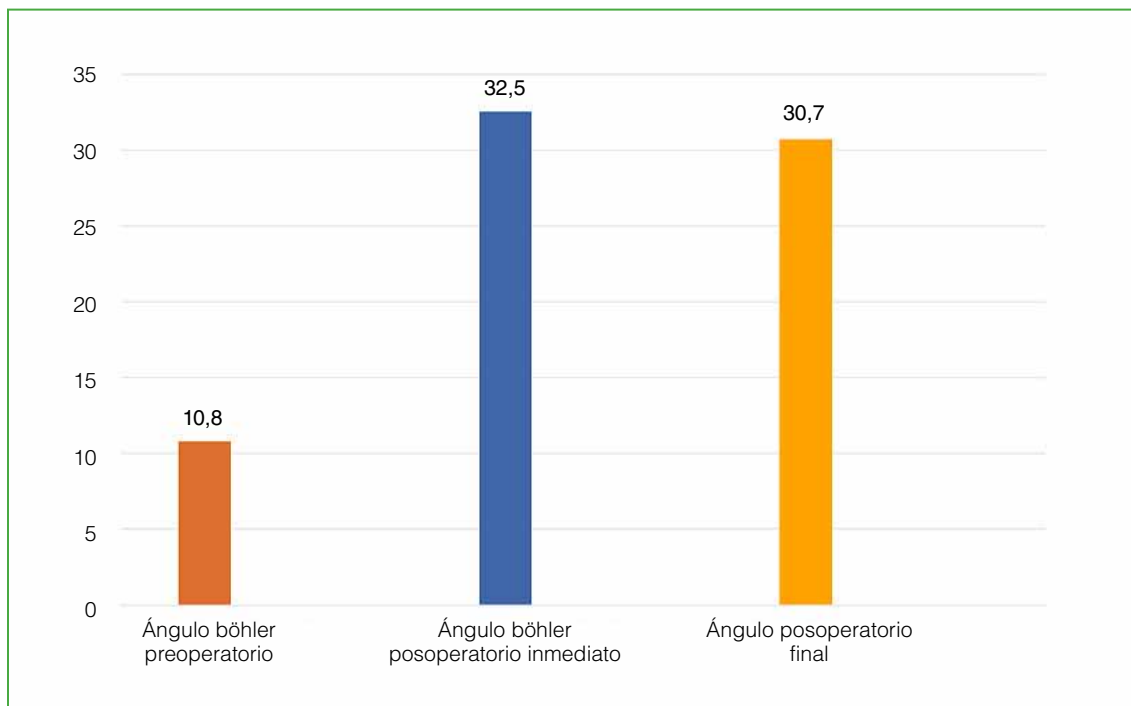
## FINDINGS

The average follow-up was  $30.8 \pm 23.2$  months. Eight patients were women and 42 were men. The age was  $39.40 \pm 14$  years (range 18-65). The trauma mechanism had been a fall from height (74%) and traffic accidents (26%). The 2% were exposed fractures and the 8% were bilateral. The fracture patterns were of the “joint depression” (63%) and “tongue” (37%) types. Based on the Sanders classification, 40 fractures were type II (50% subtype A; 42.5% subtype B; and 7.5% subtype C); 13, type III (84.6% subtype AC, 7.7% subtype AC; and 7.7% subtype BC); and one, type IV. There was involvement of the calcaneocuboid joint in 37% of cases.

The time between injury and surgery was  $9.2 \pm 6.3$  days (range 1-31). No correlation between this parameter and the restoration of the Böhler angle was found.

The AOFAS scale score was excellent in 12 patients, good in 25, regular in 12, and poor in five.

The Böhler angle was  $10.8^\circ \pm 10.4$  before surgery;  $32.5 \pm 7.73$  (range 22-54) in the immediate postoperative period; and  $30.77 \pm 8.24$  (range 17-54) after six weeks and at the end of follow-up. These values were statistically significant ( $p < 0.00001$ ) (Figure 9).



**Figure 9.** Preoperative and postoperative Böhler angle.

A loss of more than  $5^\circ$  was observed between the immediate postoperative period and the end of follow-up in four patients: one case of early withdrawal of the material due to infection and three cases of insufficient fixation in fractures with significant comminution. The patient whose osteosynthesis material was withdrawn due to infection was the only one who remained with a  $<20^\circ$  Böhler angle.

44.4% of grade I developed subtalar osteoarthritis; grade II, 7.4%; and grade III, 3.8%. There was no relation between subtalar osteoarthritis and the AOFAS scale score. All patients lost subtalar range of motion to some degree: 72.2% had moderate restriction; 11.1%, severe restriction; and 16.7%, mild restriction.

In 9.3% of cases, it was necessary to remove the osteosynthesis material: two cases were due to infection, and three cases due to peroneal tendonitis. Subtalar arthrodesis was performed in 3.7% of the fractures owing to symptomatic subtalar osteoarthritis that did not improve with the conservative treatment (Figure 10).

3.7% suffered minor complications in the wound (edge necrosis). The infection rate was 5.6% in 54 fractures. Three patients had temporary sural nerve injuries which disappeared within six months after the surgery.

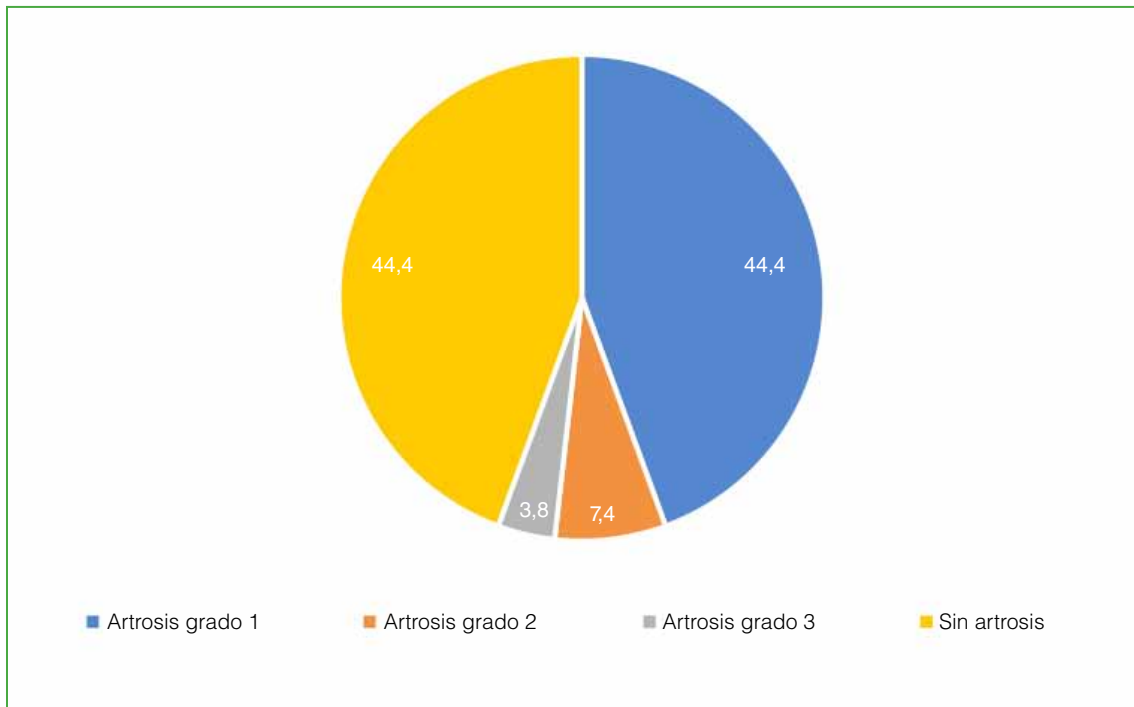


Figure 10. Degrees of subtalar osteoarthritis.

## DISCUSSION

Calcaneus fractures account for 2% of all fractures and most occur in adult patients. The issue of treatment remains controversial, as evidence shows similar results for conservative and surgical management,<sup>2, 15</sup> but most orthopedic surgeons favor surgery due to its satisfactory results.<sup>4</sup>

Surgical approaches continue to generate controversy, although minimally invasive techniques have been proven to reduce soft tissue complications and infections, in comparison with the ELA.<sup>7, 8</sup>

The sinus tarsi approach could be considered the current reference pattern, as it yields low soft tissue complications with clinical outcomes similar to the ELA.<sup>16</sup>

The significant improvement of the postoperative Böhler angle in this study proves that the calcaneus's height can be restored through this incision. The final, postoperative Böhler angle averaged 30.77°. This is linked to improved clinical outcomes.<sup>2, 7</sup> Four patients suffered a >5° Böhler angle loss, which could be ascribed to insufficient osteosynthesis in three cases, and to the early removal of the material due to infection in one patient, who had a postoperative <15° Böhler angle.

There are different options to stabilize the calcaneus through the sinus tarsi approach. Schepers recommends placing only screws in patients with fractures without comminution and good bone quality. If the implant is not stable or the calcaneus's width cannot be restored, a plate should be added.<sup>17</sup> Kir *et al.* communicate that stabilization with plates, in comparison with screws, offers a lower rate of reoperation and implant withdrawal, along

with a better reconstruction of the calcaneus's width and improved functional outcomes in Sanders type II and III fractures.<sup>18</sup> Pitts *et al.*<sup>19</sup> found no difference between plates and screws regarding postoperative Böhler and Gissane angles or wound complications. In a biomechanical study, the stability achieved with intramedullary screws is shown to be higher than with traditional plates, possibly because they are anchored to areas of greater density in the calcaneus.<sup>20</sup> In our series, we combined 2.7 mm locking plates or 3.5 mm plates with 3.5 mm, 4.0 mm and 6.5 mm cannulated screws.

In our study, the rate of minor wound complications was 3.7%, while the rate of deep infection was 5.6%. Schepers published a 4.8% of wound complications (range 0-15.4) in patients treated with the sinus tarsi approach.<sup>21</sup> Nosewic presents a systematic review and a meta-analysis, informing a 4.9% of wound complications with the sinus tarsi approach, against 24.9% with the ELA.<sup>7</sup> There have also been cases of neurovascular injury in the 9.1-25%<sup>22-23</sup> with the ELA, and in 5% with the sinus tarsi approach.<sup>24</sup> In our series, three patients suffered temporary sural nerve injuries.

Our rate of good and excellent outcomes according to the AOFAS scale (68.5%) coincides with other published results for the sinus tarsi approach.<sup>24</sup>

All patients presented some degree of stiffness in the subtalar joint. 83.3% suffered a moderate to severe loss of range of motion. This could be related to the irreversible injury of the articular cartilage.<sup>25</sup>

The reduction of the subtalar joint is very important, since a >1 mm step-off alters weight distribution in said joint and produces post-traumatic osteoarthritis.<sup>26</sup> 55.6% of our patients developed osteoarthritis, with 44.4% being grade I.

Regarding the limitations of our own research, we had only one patient with a Sanders type IV fracture, which has precluded us from assessing the treatment in this group of fractures. Secondly, the follow-up time was relatively short. While osteoarthritis did occur and subtalar arthrodesis was needed, had the follow-up been longer, perhaps the results might have shown some decline. Thirdly, there was no randomized comparison group, although the results are similar to those obtained in groups of patients treated with the sinus tarsi approach, and were also compared with the ELA.

## CONCLUSION

The sinus tarsi approach allows for an adequate exposition of the fracture and an acceptable reduction, with good and excellent outcomes in most patients and few soft tissue complications.

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# Distraction Osteogenesis Technique Using an Intramedullary Nail and an External Fixator in Large Bone Defects

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## ABSTRACT

**Introduction:** The proper treatment of bone defects represents a challenge for the orthopedic surgeon given the difficulty in restoring limb alignment without discrepancy nor infections. Multiple techniques have been described for the reconstruction of these defects. These include bone grafting, whether autologous or from a bank, the induced membrane technique, distraction osteogenesis, and, recently, the use of trabecular titanium cylinders, but none has been shown to be significantly superior to another.

**Materials and Methods:** Between 2018 and 2021, ten patients with tibial bone defects were treated by guided bone transport with intramedullary osteosynthesis. We carried out a descriptive retrospective study of this series, analyzing the magnitude of the defects, the transport time, the complications and additional surgeries that took place during the process, whether there was consolidation, and the residual deformities. The bone and functional ASAMI scores were measured at the end of the process. **Results:** The average length of the treated defects was 9.75 cm and the average external fixation index was 40.62 d/cm. At the end of the reconstructive process, 50% of the patients presented a good bone ASAMI score, 10% presented an excellent score, and 40% had a poor score. Regarding the functional ASAMI score, 20% were excellent, 30% were good, and 50% were poor. **Conclusion:** The use of fixators guided by intramedullary nails constitutes a reliable method to treat bone defects that allows treating the infection locally and systemically, shortens the times of external fixation and hospitalization, and reduces the need for reinterventions.

**Keywords:** Lengthening over a nail, Masquelet, bone defect

**Level of Evidence:** IV

## Transporte sobre clavo respetando la membrana de Masquelet en defectos segmentarios severos. Serie de casos


## RESUMEN

**Introducción:** El adecuado tratamiento de los defectos óseos se presenta como un desafío para el cirujano ortopeda, en cuanto a la dificultad en la restitución de un miembro alineado, sin discrepancia y sin infección. Se han descrito múltiples técnicas para reconstruir estos defectos, como el injerto óseo autólogo o de banco, la técnica de membrana inducida, la osteogénesis por distracción y los cilindros de titanio trabecular, pero ninguna ha demostrado ser significativamente superior a otra. **Materiales y Métodos:** Entre 2018 y 2021, 10 pacientes con defectos óseos de la tibia fueron tratados mediante transporte óseo guiado con osteosíntesis endomedular. Se realizó un estudio retrospectivo descriptivo analizando la magnitud de los defectos, el tiempo de transporte, las complicaciones y cirugías adicionales durante el proceso, si hubo consolidación y las deformidades residuales. Al final del proceso, se midió el puntaje de la ASAMI (óseo y funcional). **Resultados:** La longitud promedio de los defectos tratados fue de 9,75 cm y el índice de fijación externa promedio, de 40,62 días/cm. El 50% de los pacientes tenían un puntaje de la ASAMI óseo bueno; el 10%, excelente y el 40%, pobre al final del proceso reconstructivo. El 20% tenía un puntaje de la ASAMI funcional excelente; el 30%, bueno y el 50%, pobre. **Conclusiones:** El uso de tutores externos guiados mediante osteosíntesis es un método fiable para tratar defectos óseos, al mismo tiempo que se tratan la infección de manera local y sistémica, acortando los tiempos de tutor externo y, por lo tanto, de internación y reintervención.

**Palabras clave:** Alargamiento sobre clavo; Masquelet; defecto óseo.

**Nivel de Evidencia:** IV

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## INTRODUCTION

The proper treatment of severe segmental bone defects represents a challenge for the orthopedic surgeon, given the difficulty in restoring limb alignment without discrepancy, infections, or associated vascular or nervous injuries.<sup>1-3</sup>

One of the pillars for effective treatment is a good debridement of the infection site and any devitalized tissue around it, in order to obtain a favorable biological environment for bone and soft tissue reconstruction.

Multiple techniques have been described for bone defect treatment, including bone grafting—whether autologous or from a bank—, the induced membrane technique, distraction osteogenesis, and, recently, the use of trabecular titanium cylinders.<sup>4-6</sup>

The distraction osteogenesis method described by Ilizarov in the 1950s has been proven to be effective to treat severe bone defects.<sup>7,8</sup>

Ilizarov outlined osteogenesis by distraction or generation of new bone tissue to consolidate the pseudoarthrosis, correct deformities, eradicate infections, reestablish the limb's length, or eliminate bone defects, allowing for weight-bearing with the appropriate device. One of the difficulties posed by this treatment is the patient's low tolerance to the external fixator, as it must remain installed for a long period.

At present, the reconstruction team's efforts aim at improving the patient's tolerance to the treatment, reducing the usage time of the fixator without compromising the mechanical environment needed to achieve an adequate result.

To solve this problem, we currently use “integrated” techniques, associating the internal fixation—called LON (Lengthening Over Nail) or LOP (Lengthening Over Plate)—with the aim of diminishing the most frequent complications, related to misalignment and external fixation times.<sup>9</sup>

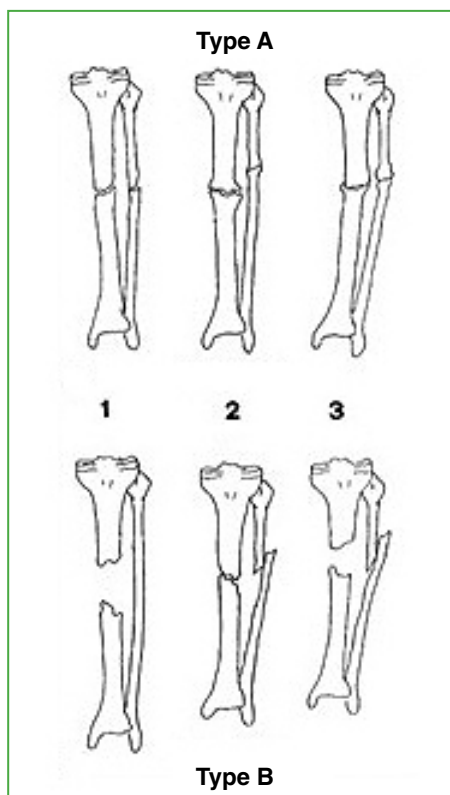
The objective of this study was to describe the functional and radiographic results, as well as the complications throughout the reconstructive process for severe bone defects, treated with bone transport by external fixation with intramedullary osteosynthesis.

## MATERIALS AND METHODS

A descriptive retrospective study was carried out in a referral center of traumatology, based on patients with segmental bone defects treated with LON transport, between January 2018 and January 2021. The study variables were retrospectively recorded from health records and images: magnitude of defects, transport time, complications according to the Paley classification<sup>10</sup>, and results based on the ASAMI score (Association for the Study and Application of the Method of Ilizarov) (bone and functional).

The inclusion criteria were: adult patients with segmental bone defects >3 cm, infection-related pseudoarthrosis (Paley classification B and beyond) (Figure 1).

**Figure 1.** Paley classification of pseudoarthrosis. Pseudoarthrosis type A (no consolidations with <1 cm of bone loss): A1 (mobile); A2, rigid (non-mobile); A2-1, no deformity; A2-2, fixed deformity. Pseudoarthrosis type B (no consolidations with bone loss >1 cm): B1, bone defect, no shortening; B2, shortening, no bone defects; B3, bone defect and shortening.



The exclusion criteria were: vascular or nervous alteration, open physis and loss of follow-up (Table 1).

**Table 1.** Sample Description

Variable	
Cases	10
Age, median (range)	69 (27-72)
Sex, n (%)	
Female	3 (30%)
Male	7 (70%)
Diagnosis, n (%)	
Osteomyelitis	3 (30%)
Exposed fracture	7 (70%)

### Treatment protocol

All procedures were performed under spinal anesthesia by the same surgical team. The protocol issued by our Limb Reconstruction Unit was followed in every case.

#### First stage

Massive debridement of devitalized tissue (Figure 2).



**Figure 2.** Intraoperative image. Debridement of devitalized tissue.

Bone stabilization with intramedullary nail covered by antibiotic-imbued cement. Soft tissue coverage. In every case, the third dead space generated by bone resections was handled using a circumferential spacer of antibiotic-imbued cement, fragmented into two hemicylinders to facilitate extraction (Figure 3).



**Figure 3.** Intraoperative image. Placing of the spacer divided into two parts.

Bone and soft tissue samples were taken in every case for microbiological and histopathological analysis. In the cases of remnant infection, the intravenous treatment was performed jointly with the Infectious Diseases Service.

### *Second stage*

The second stage is bone reconstruction (within 6-8 weeks of the first stage) by Masquelet's original technique.<sup>11</sup> The first action consists in extracting the cement spacer implanted with the same approach used in the first surgery, or raising the coverage flap. The peri-spacer membrane was always respected to preserve its osteogenic capability. The osteosynthesis was subsequently replaced by a short nail (8-9 mm) without cement cover and the canal was reamed again to obtain new samples. The external fixator's Schanz pins were inserted, using a unilateral tutor for eight patients (80%) and a circular tutor for the rest (20%). A metaphyseal corticotomy was performed in the longest remaining segment.

The last step consisted in placing the distraction system; a correct distraction of the corticotomy was verified (Figures 4 and 5).



**Figure 4.** Intraoperative image of the placing of the LRS type uniplanar external fixator.



**Figure 5.** Anteroposterior and lateral radiographs of the left leg, postoperative. See the defect, the corticotomy and the mounted system: external fixator, intramedullary nail.

All patients followed a distraction protocol of 1 mm/day, divided into four 0.25 mm distractions every 6 hours (Figure 6).



**Figure 6.** Anteroposterior radiograph of the right tibia and fibula. The observed metaphyseal-diaphyseal defect is treated with transport with uniplanar external fixator and intramedullary osteosynthesis.

### *Third stage*

Once completed the bone transport, the patients proceed to the stage of compressing the coupling site (Figures 7 and 8). This was performed with the transport system or using a dynamic compression plate without invading the focus (Figure 9).



**Figure 7.** Anteroposterior radiograph of the right tibia and fibula. The end of the process of bone lengthening is observed.



**Figure 8.** Anteroposterior and lateral radiographs of the right leg. Consolidation once removed the external fixator is observed.



**Figure 9.** Anteroposterior and lateral radiograph of the left leg. Compression of the coupling site with a 6-hole DCP plate is observed.

## FINDINGS

We analyzed 10 patients (3 women and 7 men) with osteomyelitis (3 cases) and open fractures (7 cases) who presented bone defects (Table 1). The average length of the treated defects was 9.75 cm (range 5-20), and the average rate of external fixation was 40.62 d/cm (range 36.5-54) (Table 2).

**Table 2.** Diagnosis and analysis of the results

Patient	Diagnosis	Defect (cm)	Rate of external fixation	Additional surgeries	Complications	ASAMI (bone)	ASAMI (functional)
1	Osteomyelitis	5	54	1	Yes	Good	Good
2	Exposed fracture	13	36	4	Yes	Poor	Poor
3	Exposed fracture	10	24	3	Yes	Good	Poor
4	Osteomyelitis	9	46.6	2	Yes	Good	Excellent
5	Osteomyelitis	7	42.7	2	No	Excellent	Excellent
6	Osteomyelitis	5.5	43.3	3	Yes	Good	Good
7	Exposed fracture	5	42	3	Yes	Good	Good
8	Exposed fracture	8	43.5	4	Yes	Poor	Poor
9	Exposed fracture	20	37.6	5	Yes	Poor	Poor
10	Exposed fracture	15	36.5	5	Yes	Poor	Poor

ASAMI = Association for the Study and Application of the Method of Ilizarov.

At the end of the reconstructive process, 50% of the patients had a good ASAMI bone score, 10% had an excellent score, and 40% had a poor score. The functional ASAMI score was excellent (20%), good (30%), and poor (50%). The 24% had a remnant infection.

Based on Paley's description of problems, obstacles and complications, in this series we observe:

- All patients reported eventual pain and difficulties sleeping or uncomfortableness with the distraction system.
- The obstacles —complications that require surgical intervention during the treatment— were replacements of Schanz pins owing to loosening, the most frequent complication (33%). Six Schanz pins suffered material fatigue in four patients; the mounting was subsequently changed, replacing two of them due to infection: Two patients (20%) required realigning the transport's axis, owing to deviations during the reconstructive process.
- Surgical debridement: Deep drainages were practiced on all patients to ensure that the focus remained sterile. The criterion to perform the drainage was the presence or absence of secretion from the wound, as well as other clinical and biochemical signs of infection (erythema, elevated local temperature, globular sedimentation rate, and C-reactive protein).

## Complications

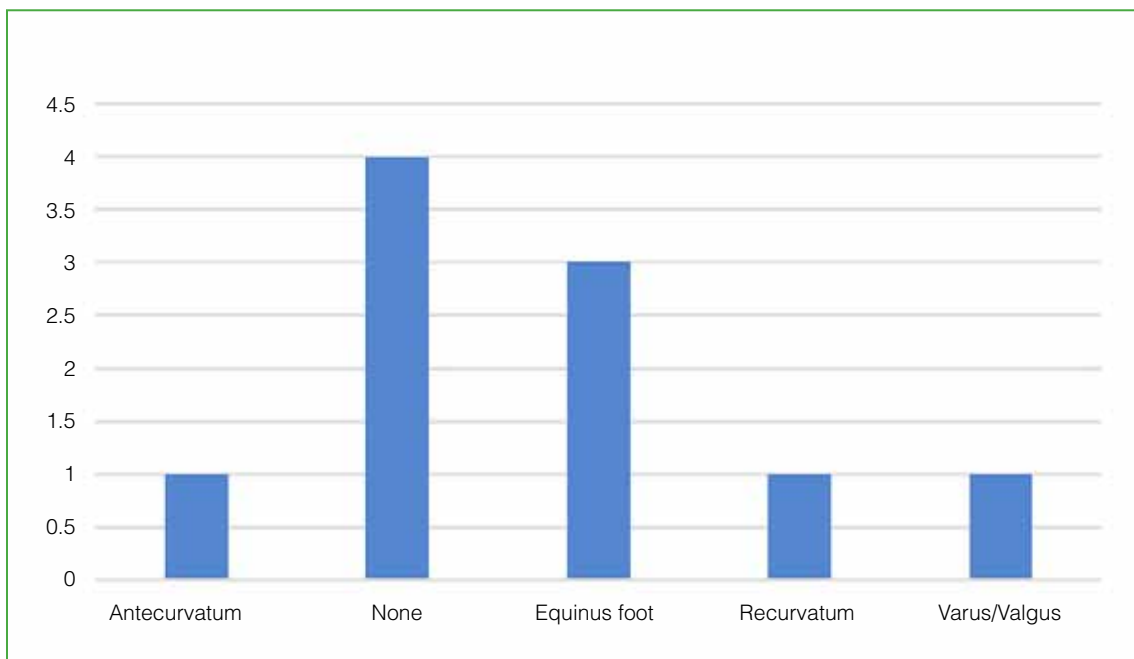
Minor complications were those which, though not solved, did not impinge on the final objective:

**Misalignments:** In our series, 60% of the patients presented some deformity at the end of the process, requiring surgery to correct the misalignment, based on deviations from the normal values (according to the ASAMI bone score) and difficulties in daily activity (Table 3).

**Table 3.** Magnitude of deformity, related to daily activity and performed surgery

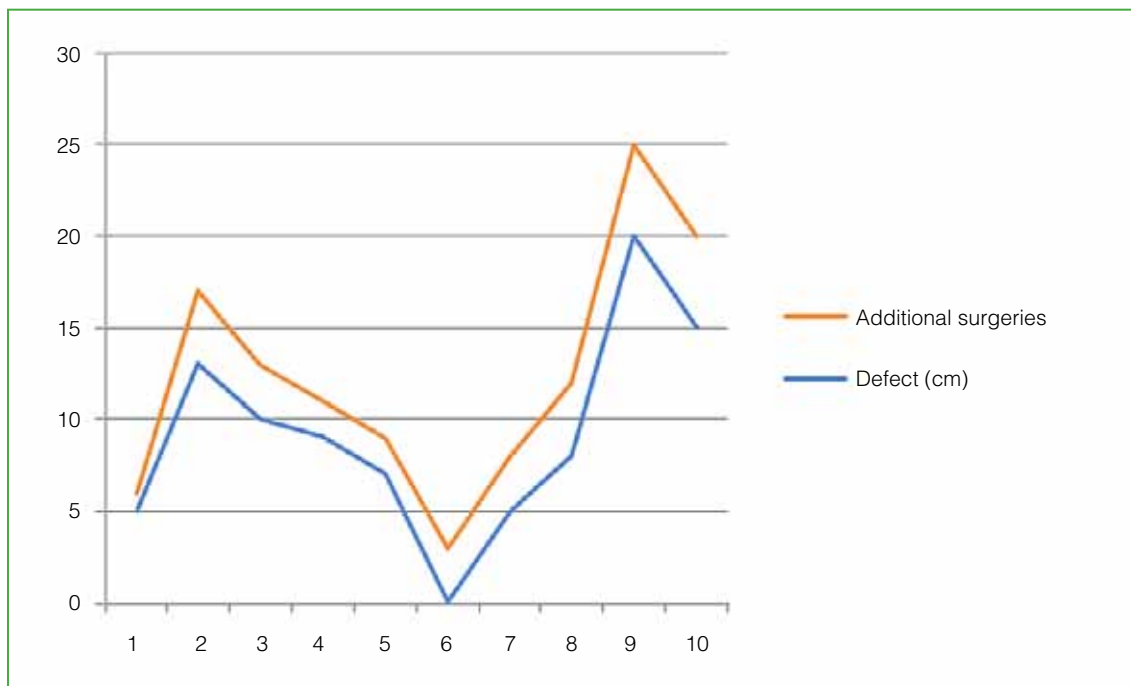
Deformity	Magnitude of deformity	Daily activity	Surgery
Ante-curvatum	+6°	Gait disturbance	Alignment
Equinus foot	Rigid Rigid Rigid	Gait disturbance Gait disturbance Gait disturbance	Achilles tendon lengthening Mobilization Achilles lengthening
Varus/Valgus	Valgus +7°	Without difficulty	Alignment
Recurvatum	+5°	Without difficulty	Alignment

- Two of these patients developed equinus stiffness, which required mobilization under anesthesia and lengthening by tenotomy.
- The rest of the deformities were a patient with a 6° ante-curvatum, a patient with recurvatum, and one with valgus deformity, the magnitude and treatment of which are summarized in [Table 3](#) and [Graph 3](#).

**Figure 10.** Deformities after the reconstruction process.

- One patient had to undergo above-the-knee amputation due to persistence of the deep infection, once concluded the reconstruction process (10%).

No major complications —i.e., those which are not resolved and preclude from attaining the final objective— occurred during surgeries. Finally, it was observed that the larger the defect's magnitude, the higher the number of surgeries required to complete the reconstruction. ([Figure 11](#))



**Figure 11.** Relationship between the magnitude of the defect and additional surgeries.

## DISCUSSION

This kind of procedure requires meticulously studying and selecting the patients. Mauffrey *et al.* described guidelines for patient optimization that make it possible to ensure an optimal biological environment for transport in bone defects, such as mechanical stability, favorable biological conditions (quitting tobacco, controlling blood glucose, nutritional streamlining), and managing endocrine metabolic changes. In a study by Brinker, patients were subjected to metabolic and endocrine tests; 80% of patients with pseudoarthrosis were reported as presenting anomalies—such as vitamin D deficiencies or thyroid and parathyroid hormones—which were not explained by any other cause.<sup>12</sup> In our center, the patients were treated by a multidisciplinary team to tackle these deficits on time, if required, although none of them had endocrine deficits.

Regarding the procedure's technical aspects, Mauffrey *et al.* describe the advantages of using external tutors on intramedullary osteosynthesis, as they allow for proper alignment and stability during the transport phase, reducing the misalignment rate to a minimum; furthermore, they make it possible to remove the tutor in earlier phases, assuming the risk of deep infections.<sup>13</sup>

Paley *et al.* carried out a comparative study (Ilizarov vs. transport on intramedullary osteosynthesis) and concluded that the transport with an external fixator on intramedullary osteosynthesis makes for considerably shorter times.<sup>14</sup> This would theoretically reduce the number of procedures by shortening distraction times and, hence, infection rates. This did not occur in our series, as all patients had to undergo at least one cleaning procedure due to clinical or biochemical signs of infection.

In their studies of transport on intramedullary osteosynthesis, Calder *et al.*<sup>15</sup> and Farsetti *et al.*<sup>16</sup> add a lower rate of misalignment and improved rehabilitation, besides the aforementioned findings. They also describe a lower rate of complications, such as stiffness in neighboring articulations (knee, ankle) or muscular contractures, thanks to the shorter usage time of the external fixator.

Comparing these theoretical advantages of alignment with intramedullary osteosynthesis, we can say that no clear benefits were observed in our series, considering the rate of misalignments at the end of the process. This may

have been due to a lack of experience with this technique, since these complications are part of the learning curve. Even so, as regards speed, we consider our results to have been similar to those communicated in the bibliography, taking into account that we had to treat severe defects. In our series, the rate of external fixation was 40.62 days/cm, a lower result compared to the series of Kocaglu *et al.*, with a mean time of external fixation of 13.5 days/cm, and Li *et al.*, with 35.7 days/cm.<sup>17</sup>

In our series, the complications coincided with those of other studies, the infection associated to Schanz pins being the most frequent (33%), along with the need to apply soft tissue coverage procedures. Deep infection linked to the intramedullary implant constituted a 23%, a significantly higher rate than other series considered.

As described by Hosny, the results and the number of complications are mostly related to the magnitude of the defects and the surgical team's lack of experience. In our series, the average defect was 9.5 cm, which produces significantly greater complications.<sup>18</sup>

The limitations of this study are the small sample, the variability of the external fixation (80% unilateral, 20% circular), and its descriptive and retrospective character.

## CONCLUSIONS

The use of external tutors guided by osteosynthesis constitutes a reliable method to treat bone defects, while infection is treated locally and systemically, reducing the times of the external tutor and, hence, of hospitalization and reoperation. In our series, the 50% obtained good and excellent functional results. Even so, these are demanding methods and are associated to a high rate of complications.

Conflict of interest: The authors declare no conflicts of interest.

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# Flexor Hallucis Longus Transfer in a Patient with Post-polio Syndrome with Posterior Tibial Tendon Dysfunction. Case Report and Surgical Technique

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## ABSTRACT

Post-polio syndrome with posterior tibial tendon dysfunction may present a flexible clubfoot and steppage gait in some patients. We describe the case of a patient who only preserved flexor hallucis longus tendon function; therefore, we decided to transfer it to the midfoot to obtain a plantigrade foot and restore dorsiflexion.

**Keywords:** flexor hallucis longus, post-polio syndrome, tendon transfer

**Level of Evidence:** IV

## Transferencia del flexor hallucis longus en un paciente con síndrome pospoliomielítico con déficit de la función del tendón tibial posterior. Reporte de un caso y técnica quirúrgica

## RESUMEN

El síndrome pospoliomielítico con déficit de la función del tendón tibial posterior puede presentarse con un pie equino flexible y marcha equina (*steppage*) en algunos pacientes. Se describe el caso de un paciente que solo conservaba la función muscular del tendón flexor hallucis longus y se decidió su transferencia al mediopié para obtener un pie plantigrado y restaurar la dorsiflexión.

**Palabras clave:** Flexor hallucis longus; síndrome pospoliomielítico; transferencia tendinosa.

**Nivel de Evidencia:** IV

## INTRODUCTION

Post-polio syndrome is a set of disabling signs and symptoms that appear, on average, 30 to 40 years after initial poliomyelitis.<sup>1</sup>

Poliovirus affects the anterior horn of the spinal cord, especially the lower region of the spinal cord; therefore, it tends to damage the lower limbs more, specifically, those whose innervation corresponds to the lumbar and sacral segments of the spinal cord, that is, from L2 to S2.<sup>2,3</sup>

The post-polio musculoskeletal involvement is not homogeneous, either in terms of the side of the body (one leg, yes, and the other leg, no), or the different myotomes in the same limb (e.g. the involvement may be higher in the L5 than in the L4 myotome); therefore, it usually produces a greater weakness in some regions than in others, which in turn gives rise to deformities known as 'poliomyelitis sequelae'. This clearly demonstrates that poliovirus damage is often asymmetric and largely random,<sup>4,5</sup> and explains why the whole body is not affected to the same extent and why not all cases are the same.<sup>6,7</sup>

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## CLINICAL CASE

A 60-year-old woman with a history of poliomyelitis in childhood consulted for gait disorder and instability of the right ankle.

On physical examination, steppage gait was observed, with a resting position of the drop foot greater than 45° (Figure 1) and without signs of contracture of the gastrocnemius-soleus complex (passive dorsiflexion of the ankle at 90° with the knee extended was achieved). The function of the gastrocnemius-soleus complex was 0, according to the modified Medical Research Council (MRC) functional strength scale. There was a lateral joint opening with marked chronic instability and the anteroposterior ankle drawer test was positive.

Muscle function test scores were 5/5 for the flexor hallucis longus (FHL) (MRC = 5) and 3/5 for the extensor hallucis longus (MRC = 3) (Figure 1). The tibialis anterior, extensor digitorum longus, peroneus longus, and peroneus brevis muscles, as well as the tibialis posterior, had no function (MRC = 0).



**Figure 1.** Muscle function of the flexor hallucis longus and dropped position of the foot.

Scores on the FAOQ (Foot and Ankle Outcomes questionnaire) and AOFAS (American Orthopaedic Foot & Ankle Society) scales were 71 and 72, respectively.

An electromyography revealed severe involvement of the right common fibular nerve (external popliteal sciatic nerve) with paralysis of the anterolateral muscles of the right leg. Radiographs showed mild signs of osteoarthritis (Figure 2).



**Figure 2.** Anteroposterior and lateral ankle radiographs Mild signs of osteoarthritis can be seen.

### Surgical technique

The patient is placed in the dorsal position, and a tourniquet is placed on the root of the thigh. A medial approach is performed over the midfoot to release the FHL (**Figure 3A**). The tendon is extracted through a posteromedial approach to the leg (**Figure 3B**) and passed through the tibiofibular interosseous membrane through an anterolateral approach (**Figure 3C**). A final approach is made on the second wedge in the dorsum of the foot, then the distal end of the tendon is slid into the extensor retinaculum and finally inserted with an interference screw in said wedge, granting the appropriate neutrality and tension (**Figure 3D**).

The lateral ligament complex is stabilized by the modified percutaneous Broström-Gould technique (**Figure 3E**).



**Figure 3.** Surgical technique. **A.** Release of the flexor hallucis longus by medial approach of the midfoot. **B.** Posteromedial extraction of the tendon. **C.** Transfer of the interosseous membrane to the anterolateral region. **D.** Tenodesis to the second wedge. **E.** Stabilization of the lateral ligament.

The foot is immobilized with a short leg cast for six weeks, without weight bearing. Then, the cast is changed for a Walker boot and, at the same time, physical therapy begins. The immobilizer is removed after 10 weeks (Figure 4).

In our patient, the transfer of the FHL to the second wedge was achieved without complications. The active range of motion at six months of follow-up was 5° dorsiflexion and 10° ankle plantarflexion. FAOQ and AOFAS scores were 77 and 80, respectively. An improvement of 6 and 8 points was achieved, respectively, over the preoperative score.



**Figure 4.** Kinesiotherapy without immobilizer (10 weeks after surgery).

## DISCUSSION

Currently, FHL transfer is widely used in Achilles tendon pathology.<sup>8,9</sup> In this type of neurological sequelae, most orthopedic surgeons prefer to use tibialis posterior tendon transfer.<sup>10-12</sup> Because this tendon was not available, transferring the only active tendon (FHL) vs. arthrodesis posed a major challenge.<sup>13</sup>

The tendon transfer of the FHL restored our patient's gait without splints, conserving the range of motion of the ankle joint, with greater stability in the gait and without injuries from the drag of the foot in the steppage gait.

FHL can be used successfully to restore dorsiflexion in patients with post-polio syndrome, without functional deficit of the tibialis posterior tendon.

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# Medial and Plantar Dislocation of the Navicular Bone Associated With a Calcaneocuboid Fracture-subluxation. Case Report

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## ABSTRACT

Isolated navicular dislocations are unusual. They are frequently associated with navicular fractures or diverse patterns of lateral column injuries. We report a case of a patient with medial and plantar navicular dislocation with a comminuted intra-articular fracture of the anterior process of the calcaneus and associated subluxation at the calcaneocuboid joint. The patient underwent closed reduction and Kirschner wire stabilization in the Emergency Service. As part of the deferred treatment, talonavicular-cuneiform and calcaneocuboid 2.0 mm bridge plates were temporarily placed and osteosynthesis material was removed 5 months later. The AOFAS score was excellent in the one-year follow-up. **Conclusion:** An accurate diagnosis, ruling out lateral column injuries, should be done in the Emergency Service. Bridge plate stabilization is a valid option to prevent loss of reduction, which is observed when removing Kirschner wires, allowing early weight-bearing.

**Keywords:** Chopart injuries, navicular bone, calcaneal fractures

**Level of Evidence:** IV

## Luxación medial y plantar del hueso navicular asociada a fractura-subluxación calcaneocuboidea. Presentación de un caso

## RESUMEN

Las luxaciones del escafoides aisladas y sin fractura son poco frecuentes. Por lo general, se presentan asociadas a fracturas del escafoides o a diversos patrones de lesión de la columna lateral. Presentamos el caso de un paciente con luxación medial y plantar del hueso navicular y fractura conminuta del proceso anterior del calcáneo y subluxación calcaneocuboidea. En el Servicio de Urgencia, se procedió a la reducción cerrada y la estabilización con agujas de Kirschner y, como tratamiento diferido, se colocaron placas en puente astragalonavicular-cuneiforme y calcaneocuboidea de 2,0 mm, en forma transitoria, y el material de osteosíntesis se retiró a los 5 meses. El puntaje de la escala de la AOFAS fue excelente al año de seguimiento. **Conclusión:** Es necesario llegar a un diagnóstico adecuado descartando lesiones de la columna lateral y reducir esta lesión en la atención de urgencia. La estabilización con placas en puente es una opción válida que podría evitar la pérdida de la reducción que se observa al retirar los clavos de Kirschner y permite una carga precoz.

**Palabras clave:** Lesión de Chopart; luxación; hueso navicular; fractura de calcáneo.

**Nivel de Evidencia:** IV

## INTRODUCTION

Dislocations of the navicular bone without fracture are rare.<sup>1,2</sup> Similar injuries have been published, but, in general, they occur in association with fractures of the navicular bone or other bones of the midfoot.<sup>1-13</sup> This is due to the stability conferred by the anatomy of the tarsal bones in the midfoot which are held firmly by strong dorsal and plantar ligaments.<sup>14</sup> In a review of published studies, we found 17 cases between 1924 and 2016, the latter being the last reference found. It has been claimed that dislocation of the navicular bone without fracture is anatomically impossible.<sup>7</sup> The concept of interdependence between the medial and lateral columns has also been proposed, where the dislocation of one column is accompanied by a ligament or bone lesion of the other.<sup>4</sup> The

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various treatments already reported for these injuries have included closed reduction and casting, closed reduction with percutaneous pinning, open reduction and Kirschner wire fixation, open reduction with internal fixation, and osteodesis combined with external fixation.

We present the case of a patient with dislocation of the navicular bone associated with a comminuted fracture of the anterior process of the calcaneus with calcaneocuboid subluxation and treated with bridge plating through the calcaneocuboid and talonavicular-cuneiform joints.

The objective of this study is to present a rare case and a review of the literature.

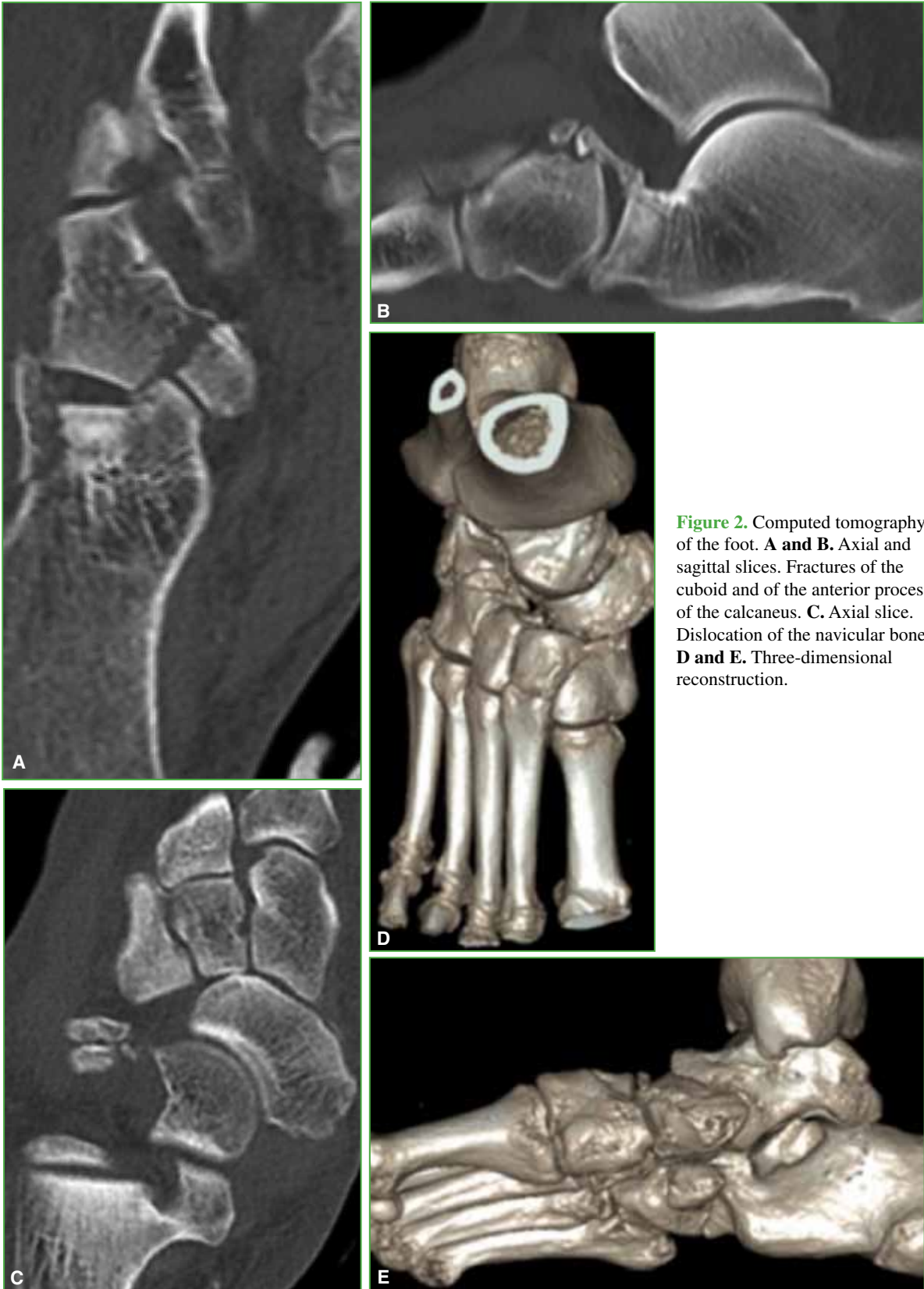
## CLINICAL CASE

A 39-year-old patient, with no relevant medical history, suffered a blunt crushing injury to his right foot (a pickup truck ran over his foot) while doing rural work. He was admitted to the emergency service due to pain in the right midfoot and marked deformity in the medial longitudinal arch, as well as moderate edema. He had no sensory-motor deficit and capillary nail refill was preserved. No associated lesions were observed on the rest of the body.

Anteroposterior, lateral, and oblique foot radiographs were taken (Figure 1) and a CT scan was performed (Figure 2). A dislocation of the navicular bone associated with a comminuted fracture of the anterior process of the calcaneus and cuboid with calcaneocuboid subluxation was observed.



**Figure 1.** Anteroposterior, lateral, and oblique radiographs of the foot. Dislocation of the medial plantar navicular bone and comminuted fracture of the anterior process of the calcaneus with calcaneocuboid subluxation.



**Figure 2.** Computed tomography of the foot. **A and B.** Axial and sagittal slices. Fractures of the cuboid and of the anterior process of the calcaneus. **C.** Axial slice. Dislocation of the navicular bone. **D and E.** Three-dimensional reconstruction.

Three hours after admission and after carrying out the corresponding complementary studies, the patient was transferred to the operating room where closed reduction and stabilization maneuvers were performed using a Kirschner pin taking the first cuneiform, navicular and cuboid. All procedures were performed with radioscopic assistance. The extremity was immobilized with a posterior ankle splint and postoperative radiographs were taken, which showed an acceptable joint reduction; the definitive fixation was scheduled (Figure 3).

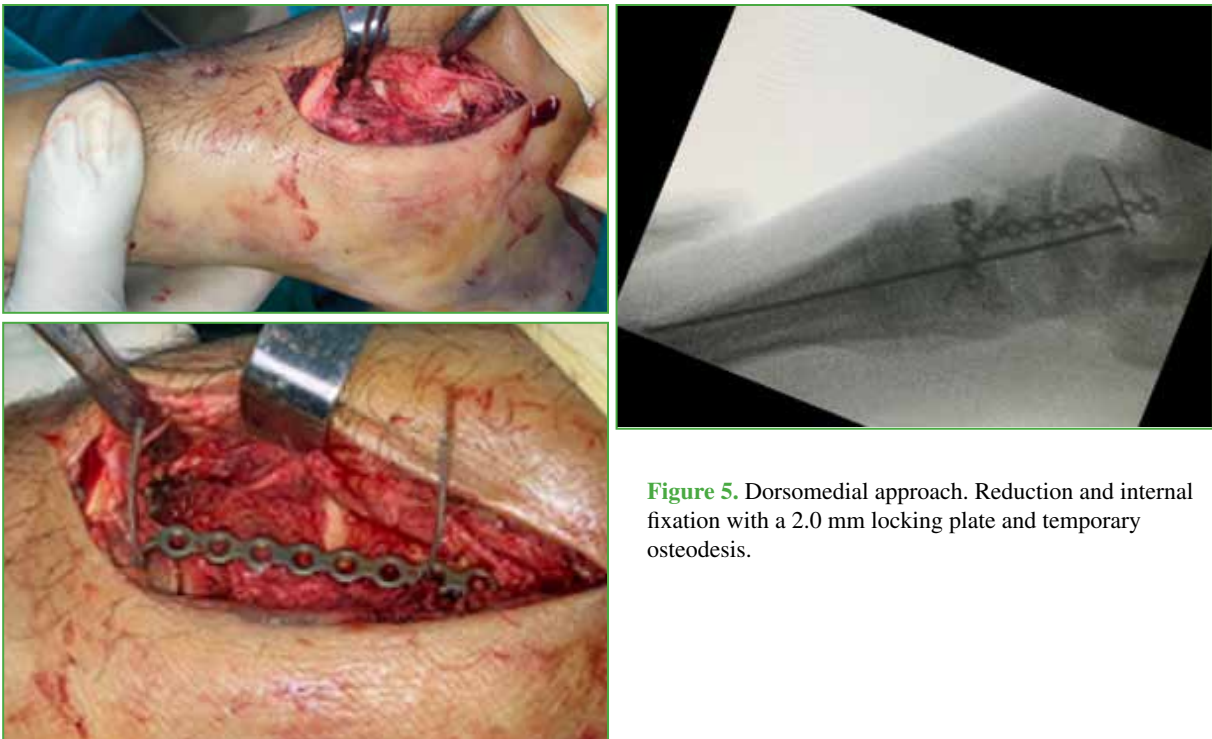


**Figure 3.** Anteroposterior and lateral radiographs of the foot. Kirschner wire reduction and stabilization in emergency care.

After a week of follow-up and after verifying the correct evolution of the soft tissues (Figure 4), definitive fixation was carried out. In the operating room, the patient was placed in the dorsal decubitus position and a tourniquet was placed on the thigh. Initially, a dorsomedial incision was made, centered at the talonavicular-cuneiform level, where it was possible to visualize the unrestrained dislocation of the navicular bone once the Kirschner pin was removed (Figure 5). It was decided to perform open reduction by applying axial traction and lateral compression, with temporary stabilization using a Kirschner pin and then, with a 2.0 mm locking T-plate (Figure 6), to perform the definitive talonavicular-cuneiform fixation. A dorsolateral approach was made at the level of the calcaneocuboid joint where an articular subsidence fracture was visualized at the level of the calcaneus with a calcaneocuboid plantar subluxation. A bone impactor was used to elevate the articular surface to its normal position, an autologous cancellous graft from the posterior calcaneal tuberosity was placed, joint congruence was restored and fixated with a 2.0 mm T-type locking calcaneocuboid bridging plate. (Figures 7 and 8).



**Figure 4.** Favorable soft tissue evolution after reduction in emergency care.



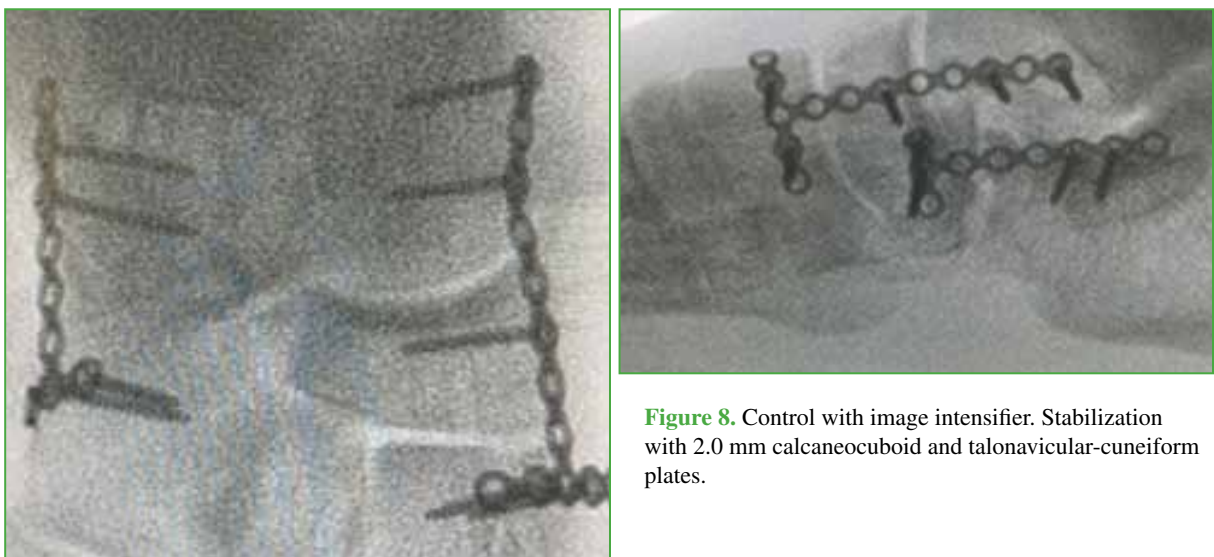
**Figure 5.** Dorsomedial approach. Reduction and internal fixation with a 2.0 mm locking plate and temporary osteodesis.



**Figure 6.** Anteroposterior and lateral control of the foot with fluoroscopy. Stabilization with talonavicular-cuneiform plate.



**Figure 7.** Calcaneocuboid lateral approach. The articular subsidence of the anterior process of the calcaneus and the reconstruction is observed.



**Figure 8.** Control with image intensifier. Stabilization with 2.0 mm calcaneocuboid and talonavicular-cuneiform plates.

First of all, the medial column was stabilized, since it did not have any fractures and this allowed it to recover the adequate length once the joints were reduced. Secondly, the lateral column, which did present comminuted fractures, was fixated. The wounds were closed by planes and the extremity was immobilized with a posterior ankle splint. Non-weight-bearing anteroposterior and lateral radiographs of the foot were taken in the immediate postoperative period. In the third, sixth, and twelfth months of follow-up, they were repeated, with weight-bearing (Figure 9).



**Figure 9.** Anteroposterior and lateral radiographs of the foot, three months after the operation.

In the postoperative period, flexion-extension movements of the ankle began in the second week and of the subtalar joint in the fourth week, guided by the Kinesiology team. From the fourth week to the eighth week, partial weight-bearing was allowed with a Walker boot; then, full weight-bearing was allowed.

The suture was removed after 15 days, the wounds had a good evolution and removal of the osteosynthesis material was planned after five months, because the implants were placed as a bridge through the calcaneocuboid and talonavicular-cuneiform joints until ligaments had healed. No signs of necrosis of the navicular bone were observed. The presence of osteoarthritis in the calcaneocuboid, talonavicular-cuneiform and subtalar joints was evaluated after one year of follow-up, which did not correlate with the patient's symptoms (Figure 10). Grade 1 osteoarthritis was detected in the different joints.<sup>15</sup>

The AOFAS scale score was 92, an excellent result. The level of patient satisfaction with the procedure was high and, at present, he carries out his usual tasks normally.



**Figure 10.** Anteroposterior and lateral radiographs of the foot, 12 months after surgery.

## DISCUSSION

The isolated and complete dislocation of the navicular bone can present various patterns of injury in the lateral column with calcaneocuboid fracture-subluxation,<sup>4</sup> cuboid fracture,<sup>12</sup> fifth metatarsal base fracture,<sup>10</sup> third and fourth metatarsal fracture with calcaneocuboid fracture-dislocation,<sup>9</sup> and fracture of the second to fourth metatarsal, cuboid and intermediate cuneiform.<sup>15,16</sup> This is consistent with Dhillon and Nagi's all-or-nothing concept,<sup>4</sup> whereby injury to one of the columns can affect the other.

The mechanism of the injury is unknown. Dhillon and Nagi postulate that a violent pronation/abduction movement generates a cuneonavicular disruption leading to a 'nutcracker' mechanism in the lateral column. The fore-foot can dislocate in a dorsolateral or inferolateral direction depending on whether the deforming force is plantar or dorsal. Pathria et al.,<sup>9</sup> and Dixon<sup>10</sup> have proposed other mechanisms.

The proper treatment of these injuries requires a correct diagnosis in emergency care, achieving reduction and stabilization through Kirschner nails or external fixators. Subsequently, it should be evaluated if there are associated fractures in the lateral column that require osteosynthesis. It is essential to preserve, as much as possible, the length of both medial and lateral columns, maintaining the best range of motion in the talonavicular and cuboid-metatarsal joints.

In our case, we performed reduction during emergency care and stabilization with Kirschner pins; then, when the soft tissues were ready, we performed internal fixation of the fracture of the anterior process of the calcaneus with a calcaneocuboid bridging plate. This type of stabilization was carried out because there was great comminution that made distal fixation in the calcaneus impossible and also because of the instability in said joint. In the medial

column, internal fixation was performed by fixating the navicular to the talus and cuneiform bones with a bridge plate. This type of treatment is similar to the concept of plates in Lisfranc injuries.<sup>17</sup> In most published cases, definitive Kirschner wire stabilization of unstable joints is performed, causing complications such as pin intolerance and loss of reduction after nail removal. The excellent result on the AOFAS scale and the Chopart and subtalar osteoarthritis signs are similar to those reported in other publications.<sup>3,4,6</sup>

One of the limitations of this study is the follow-up period, which should be longer in order to control the appearance of complications. It would also be appropriate to evaluate our patient with others who suffer the same symptoms in order to increase the casuistry and, thus, be able to reach a more appropriate conclusion.

## CONCLUSIONS

Isolated navicular dislocations are rare and are usually associated with lateral column injuries. They must be properly diagnosed and reduced in emergency care, and definitive treatment will depend on the associated lateral column injuries. Bridge plate stabilization is a valid option that could prevent the loss of reduction seen in the removal of the Kirschner pins and also allow early weight-bearing.

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# Tillaux Fracture in Adults. Case Report and Literature Review

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## ABSTRACT

**Introduction:** The fracture of the anterolateral region of the distal tibial epiphysis, or Tillaux-Chaput tubercle, is known as Tillaux fracture. It is an exceptional entity in adults, but it has significant importance because it affects the tibiotalar joint surface, the stability of the syndesmosis, and, in some cases, the fibular notch. We present the case of a 45-year-old woman treated in the Emergency Service due to rotational trauma to the left ankle and functional impairment and pain in the anterolateral region of the ankle. The radiographs led to the suspicion of a fracture line corresponding to the Tillaux-Chaput tubercle. Therefore, a CT scan was performed, which confirmed a Tillaux fracture with a >2 mm displacement and involvement of the fibular notch. The patient underwent open reduction and internal fixation. The fracture consolidated after 3 months. One year after surgery, her clinical and functional status was excellent. **Conclusion:** Diagnostic suspicion through meticulous physical examination and anamnesis and confirmation by imaging studies are essential for the proper management of rare fracture patterns, such as Tillaux fractures.

**Keywords:** adult, fracture fixation, Tillaux fracture, ankle

**Level of Evidence:** IV

## Fractura de Tillaux en adultos. Reporte de un caso y revisión de la bibliografía

## RESUMEN

**Introducción:** La fractura de la región anterolateral de la epífisis distal de la tibia, o tubérculo de Tillaux-Chaput, es conocida como fractura de Tillaux. Se trata de una fractura extremadamente rara en los adultos, pero tiene una importancia fundamental, porque compromete la superficie articular tibio-astragalina, la estabilidad de la sindesmosis, y, en algunos casos, la incisura peronea. Se presenta el caso de una mujer de 45 años con un traumatismo rotatorio del tobillo izquierdo e impotencia funcional y dolor en la región anterolateral del tobillo. Las radiografías generaron la sospecha de un trazo de fractura correspondiente al tubérculo de Tillaux-Chaput. Por lo tanto, se realizó una tomografía computarizada que confirmó una fractura de Tillaux, que tenía un desplazamiento >2 mm y compromiso de la incisura peronea. La paciente fue sometida a reducción abierta y fijación interna. La fractura consolidó a los 3 meses. Al año de la cirugía, su estado clínico y funcional es excelente. **Conclusión:** La sospecha diagnóstica que surge de una completa anamnesis y un meticuloso examen físico, y la confirmación mediante estudios por imágenes son esenciales para abordar correctamente patrones de fracturas raras, como la fractura de Tillaux.

**Palabras clave:** Adulto; fijación de fractura; fractura de Tillaux; tobillo.

**Nivel de Evidencia:** IV

## INTRODUCTION

Tillaux fracture is the fracture of the anterolateral region of the distal epiphysis of the tibia, known as the Tillaux-Chaput tubercle, the insertion site of the anterior inferior tibiofibular ligament (AITFL), the anterior component of the syndesmosis ligament complex.<sup>1-4</sup> A Tillaux fracture can be isolated or part of a more complex fracture pattern. Some authors consider this fragment as a fourth malleolus or anterior malleolus.<sup>4</sup> The isolated form is more frequent in the adolescent population, during the period of closure of the physis, an entity included within transitional fractures; even so, it has a prevalence of only 2.5% of all ankle fractures.<sup>1,4,5</sup> On the contrary, in the adult

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population, the isolated Tillaux fracture is very rare.<sup>4,6-9</sup> This is because the most common mechanism of injury is supination and external rotation, which causes stress and tear in the AITFL almost constantly, because the ligament has less strength than bone.<sup>6-9</sup> When Tillaux-Chaput's tubercle is affected, the stability of the syndesmosis and the congruence of the tibiotalar articular surface and the fibular notch are usually compromised.<sup>3,4,10,11</sup> Therefore, if this fracture is not treated adequately and timely, it can cause pain, functional impairment, and post-traumatic osteoarthritis.<sup>3,4,10,11</sup>

In the literature, there is scant information on Tillaux's fracture in adults. The objective of this presentation is to report a case of a Tillaux fracture in an adult and to analyze the most important aspects of diagnosis and therapeutic options.

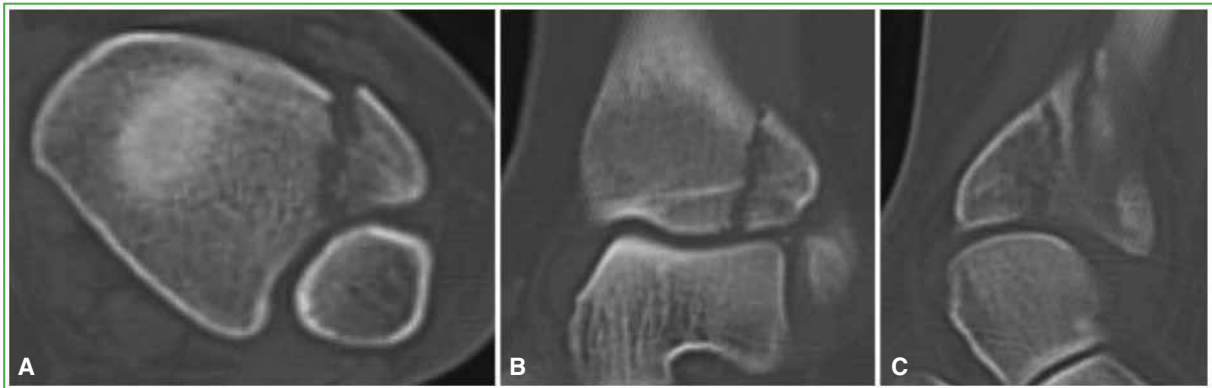
## CLINICAL CASE

A 45-year-old woman, with no relevant medical history, suffered a left ankle injury due to a rotational mechanism. She was initially treated in the emergency service. The physical examination evidenced the patient's inability to bear weight on that limb, functional impairment in the ankle, and mild edema and pain located in the anterolateral region. The neurovascular examination was normal. Anteroposterior and lateral ankle radiographs were requested, showing a fracture line in the distal anterolateral region of the tibia (Figure 1). To confirm the fracture, a CT scan was requested, which revealed an isolated fracture in the anterolateral region of the tibia, corresponding to Tillaux-Chaput's tubercle (Figure 2).

As it was an intra-articular fracture with a displacement  $>2$  mm and involvement of the fibular notch, surgery was indicated, which was performed four days after the trauma.



**Figure 1.** **A.** Preoperative anteroposterior radiograph of the left ankle. A vertical fracture line (arrow) is observed in the lateral region of the distal epiphysis of the tibia. **B.** Preoperative lateral radiograph of the left ankle. There is a superposition of the Tillaux-Chaput fragment (dotted line) and the distal epiphysis of the tibia in the anterior region.



**Figure 2.** CT scan of the left ankle, axial (A), coronal (B) and sagittal (C) slices, showing displacement, articular gap, and integrity of the Tillaux-Chaput fragment.

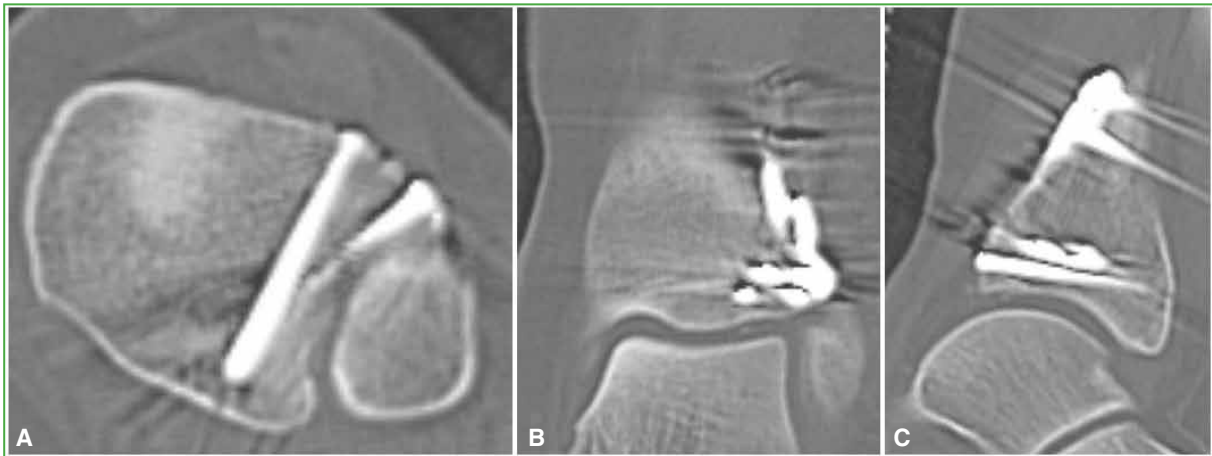
### Surgical technique

The patient was placed in the dorsal decubitus position, and anesthesia was administered, which consisted of neuroleptanalgesia and regional anesthesia of the limb. An anterolateral approach was performed, dividing between the extensor digitorum longus and the fibularis tertius by planes, and the superficial fibular nerve was repaired laterally. Subsequently, when the fracture line was identified, the focus was curetted, and reduction was achieved with a clamp. It was temporarily stabilized with pins and an adequate reduction was verified under direct vision and by fluoroscopy. Two 2.0 mm full-thread cannulated screws were then placed applying compression; and a 2.7 mm 'T' locking plate was added to increase support (Figure 3).



**Figure 3.** Intraoperative clinical image. The reduction and stabilization achieved through an anterolateral ankle approach are shown.

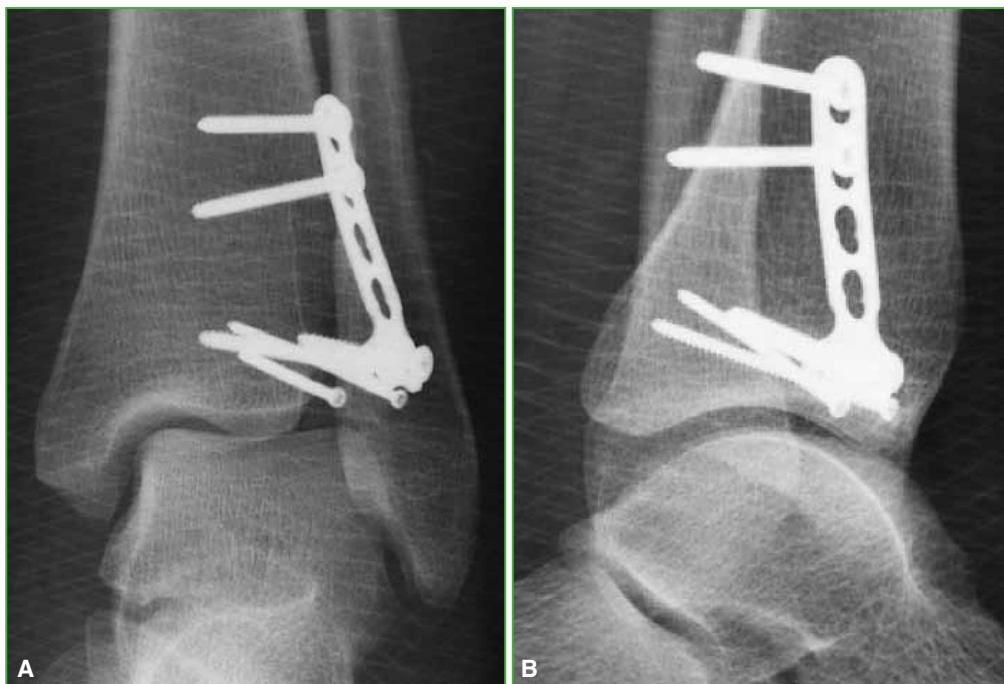
The reduction was controlled again and the adequate stability of the syndesmosis was verified. Primary closure was performed and a posterior ankle splint was placed to protect the wound. The postoperative joint reduction was monitored with a CT scan (Figure 4).



**Figure 4.** CT scan of the left ankle, axial (A), coronal (B), and sagittal (C) slices, showing the anatomical reduction of the Tillaux-Chaput fragment.

Postoperative management consisted of splint removal after a week, with a change to a non-weight-bearing Walker boot for six weeks. During this time, the patient began active and passive ankle range of motion exercises. In the sixth week, the Walker boot was removed and progressive partial weight-bearing was authorized and, in the eighth week, full weight-bearing was allowed.

Serial radiographic controls were performed 15 days, one month, three months, and one year after surgery (Figure 5).



**Figure 5.** A. Postoperative anteroposterior radiograph of the left ankle. No signs of secondary displacement or osteoarthritis are detected. B. Postoperative lateral radiograph of the left ankle. There are no signs of secondary displacement or osteoarthritis.

One year after surgery, the range of motion was comparable to the contralateral ankle and the AOFAS (*American Orthopedic Foot and Ankle Society*) score was 90/100, due to sporadic pain with sports activities.

## DISCUSSION

In 1872, Tillaux described the anterolateral fragment of the tibia upon discovering, in a cadaveric study, that the stress to which he subjected the AITFL caused a fracture of the tibial fragment; years later, he was supported by Chaput who observed him in clinical cases.<sup>4,12</sup> Tillaux fracture is diagnosed mainly in the adolescent population, this is because the anterolateral region of the distal tibia is the last zone of closure of the physis and the resistance of the physis is lower than that of the ligaments, which creates an avulsion of the fragment.<sup>1,2</sup> On the contrary, in adults, the incidence of this fracture is extremely rare, because bone resistance is greater than ligament resistance; therefore, ligament injuries prevail.<sup>7,8,13</sup> The mechanism of injury to the Tillaux-Chaput fragment, in isolated or complex fractures, is fundamentally supination and external rotation of the foot.<sup>4,6-9,12,13</sup> The lesion begins in the anterolateral region of the tibia, causing the avulsion or ligament injury, and spreads to the fibula and posterior and medial structures.<sup>3,13,14</sup> Almost all Tillaux-Chaput tubercle fractures are part of complex ankle fractures, with an approximate prevalence of 25%. An isolated Tillaux fracture occurs when the energy of the trauma is concentrated on this tubercle, without continuing its rotational direction.<sup>15</sup>

The risk of not noticing this fracture is very high.<sup>4,7-9,12,13</sup> Therefore, its early diagnosis depends fundamentally on diagnostic suspicion, an exhaustive physical examination and a correct interpretation of the complementary studies. Clinically, it is easy to confuse it with a sprain of the lateral ankle ligament complex.<sup>6,8,13</sup> Considering our case and the reviewed literature, the most reported symptoms and signs are the inability to bear weight on the affected limb, slight edema and pain focused on the anterolateral region, and absence of pain in the medial and lateral malleolus.<sup>6,8,9,13,16</sup> Given clinical suspicion, radiographs should be requested that include the 20° internal oblique projection, since this projection avoids the superimposition of the medial cortex of the fibula with the vertical line of the fracture, therefore allowing better visualization of the anterolateral region of the tibia and, thus, preventing it from going unnoticed.<sup>1,4,17</sup> In addition, it is essential to request a computed tomography, which serves to confirm when there is a diagnostic doubt with the radiograph and allows establishing the characteristics of the fragment with more precision, such as size, joint gap, displacement and comminution.<sup>9,12,13</sup> These characteristics will define the treatment and, if surgery is chosen, help with planning.<sup>11,17</sup>

The Tillaux fracture challenges us with some aspects that can affect the future function and integrity of the joint. On the one hand, the tear of the anterior syndesmosis, even though the AITFL only contributes 35% of the total resistance; on the other hand, the disruption of the fibular notch, which can generate instability in the tibiotalar mortise and in the inferior tibiofibular relation, respectively.<sup>3,4,14</sup> This leads to the translation and valgus deviation of the talus, with an alteration in the distribution of weight load on the articular surface, which can cause early damage to the cartilage.<sup>3,10,14</sup> Another aspect to consider is joint congruence, where a gap >2 mm can accelerate articular cartilage degeneration.<sup>1,6,10</sup> Therefore, if this injury is not adequately treated, it can lead to post-traumatic osteoarthritis, with its subsequent functional consequences.<sup>10,14</sup>

The goal of surgery should be to achieve anatomic reduction and stable fixation. For this, multiple techniques have been published, such as the fixation of the Tillaux fragment with a 4 mm partially-threaded cannulated screw.<sup>4,13</sup>

Feng et al. published the largest case series of Tillaux fractures with 16 patients,<sup>6</sup> of whom were treated with one or two differentially-threaded cannulated screws using arthroscopic assistance. Arthroscopy, in these cases, has the advantage of lower morbidity, faster recovery, and the possibility of inspecting the tibiotalar and syndesmosis joint, in order to detect unsatisfactory reductions that were not perceived by fluoroscopy.<sup>6</sup> In fragments <5 mm, fixation is difficult due to the risk of fragmentation, but the AITFL can be reinserted with an anchor to restore ligament stability of the syndesmosis.<sup>15</sup> Cases of conservative treatment with immobilization using a posterior ankle splint for 6-8 weeks have been reported.<sup>8,9</sup> These cases presented a fragment with <2 mm displacement and stable syndesmosis. Our case is the only one published in which fixation was performed with a plate supplementing the compression of the cannulated screws. It was decided to add the plate with a support function to provide greater stability to the shearing forces and to be able to carry out early mobilization of the ankle without risk of secondary displacement. Therefore, we believe that the fixation to be sought allows sufficient stability to start early rehabilitation and, in turn, this is determined by the size and bone quality of the fragment.

As it is a unique case, we have the limitation of not being able to draw solid conclusions. However, we believe that the Tillaux fracture in adults is an entity that should be suspected in all ankle trauma with exquisite pain in the anterolateral region. In addition, anteroposterior, lateral, and oblique radiographic projections help to define the diagnosis, while computed tomography confirms it and establishes the treatment, as it allows determining the characteristics of the fragment and planning the surgical strategy.

Conflict of interest: The authors declare no conflicts of interest.

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# Endoscopic Spring Ligament Repair. Anatomic Evaluation of Portal Safety

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## ABSTRACT

**Introduction:** Calcaneonavicular ligament injury has been described as a cause of adult flat foot deformity. The objective of this study is to describe modified portals for the diagnosis and treatment of injuries to the superomedial bundle of the calcaneonavicular ligament and to evaluate the safety of the portals used. **Materials and Methods:** We performed a cadaveric specimen study on 6 feet, where we reproduced a lesion of the superomedial bundle of the calcaneonavicular ligament with a radiofrequency ablation device and repaired it endoscopically. Two modified portals were created for the approach and an anatomical dissection was performed to assess the safety of the portals in relation to the anatomical structures. The first portal was placed immediately proximal to a line drawn from the tip of the medial malleolus toward the center of the heel; the second portal was placed 0.5 cm proximal to the posterior tibial tendon insertion into the navicular bone, guided by transillumination. If needed, an accessory portal was placed halfway between the two previously described portals immediately dorsal to the posterior tibial tendon. **Results:** In all cases, ligament repair was achieved with the endoscopic procedure. In the anatomical dissection of the portals, we observed an average distance of 11.83 mm from the proximal portal and 9.66 mm from the distal portal to neurovascular structures. **Conclusion:** Modified portals are safe and allow direct visualization of the superomedial bundle of the calcaneonavicular ligament to perform endoscopic repair.

**Keywords:** spring ligament, posterior tibial tendon dysfunction, endoscopic repair of the spring ligament, tendoscopy, progressive collapsing foot deformity, adult flatfoot

**Level of Evidence:** IV

## Seguridad de los portales para la reparación endoscópica del ligamento calcaneonavicular: estudio cadavérico

## RESUMEN

**Introducción:** La lesión del ligamento calcaneonavicular ha sido descrita como una de las causas de la deformidad en el pie plano del adulto. El objetivo de este artículo es describir portales modificados para el diagnóstico y la reparación endoscópica de las lesiones del fascículo superomedial del ligamento calcaneonavicular y evaluar la seguridad de los portales utilizados. **Materiales y Métodos:** Se llevó a cabo un estudio cadavérico con seis preparados reproduciendo una lesión del fascículo superomedial del ligamento calcaneonavicular con una punta de corte de radiofrecuencia y la posterior reparación endoscópica. Se crearon dos portales modificados para el abordaje. Luego se procedió a la disección anatómica para evaluar la seguridad de los portales en relación con las estructuras anatómicas. El primer portal se realiza inmediatamente proximal a una línea trazada desde la punta del maléolo medial dirigida al centro del talón, el segundo portal se emplaza 0,5 cm proximal a la inserción del tendón tibial posterior en el escafoides por transiluminación. Si es necesario, se coloca un portal accesorio inmediatamente dorsal al tendón tibial posterior a mitad de camino entre los dos portales antes descritos. **Resultados:** En todos los casos, fue posible la reparación del ligamento con el procedimiento endoscópico. En la disección anatómica de los portales, se observó una distancia promedio a las estructuras vasculonerviosas de 11,83 mm del portal proximal y de 9,66 mm del portal distal. **Conclusión:** Los portales modificados, son seguros y permiten la visualización directa del haz superomedial del ligamento calcáneo-navicular y su reparación endoscópica.

**Palabras clave:** Ligamento calcaneonavicular; disfunción del tendón tibial posterior; reparación endoscópica; tendoscopia; colapso progresivo del arco; pie plano del adulto.

**Nivel de Evidencia:** IV

Received on August 7<sup>th</sup>, 2022. Accepted after evaluation on December 5<sup>th</sup>, 2022 • Dr. HÉCTOR MASARAGIAN • masa@cirugiadelpie.net  <https://orcid.org/0000-0001-5971-5121>

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## INTRODUCTION

The calcaneonavicular ligament complex or *spring ligament* is usually formed by two components, the superomedial ligament and the inferior ligament.<sup>1-3</sup> The superomedial ligament is quadrangular in shape and merges with the inferior ligament. It also fuses with components of the deltoid ligament and talonavicular ligament. It has a fibrocartilage surface in its central area that supports the talus head, clearly differentiable during the endoscopic procedure. The inferior ligament is trapezoidal and supports the inferior side of the talus head, with a triangular surface of dorsal fibrocartilage.<sup>1</sup> Taniguchi et al. described a third fiber ligament that is independent of the other two ligaments, also known as the medioplantar oblique ligament. Its origin lies in the coronoid fossa between the anterior and medial facets of the calcaneus and goes towards its insertion at the edge of the navicular.<sup>2</sup>

Functionally, the spring ligament acts as a main stabilizer of the medial arch and is the first static support of the talonavicular joint.<sup>4</sup>

The sequelae of spring ligament injury are described in the literature.<sup>5,6</sup> The involvement of this ligament is frequent and even as important as that of the posterior tibial tendon (PTT).<sup>4</sup> PTT dysfunction could lead to stress on the deltoid ligament or the spring ligament, which is lengthened and eventually injured. On the other hand, an initial injury to the spring ligament increases the strain on the PTT, which causes PTT dysfunction.<sup>6</sup> The same happens in ankle and foot misalignments that produce a medial overload on structures that maintain the position of the arch of the foot and predispose to long-term mechanical failure.

In this study, an endoscopic repair technique is described, using modified portals for spring ligament repair and eventual PTT lesions.

The objective of this study was to evaluate the safety of modified portals for endoscopic spring ligament repair.

## MATERIALS AND METHODS

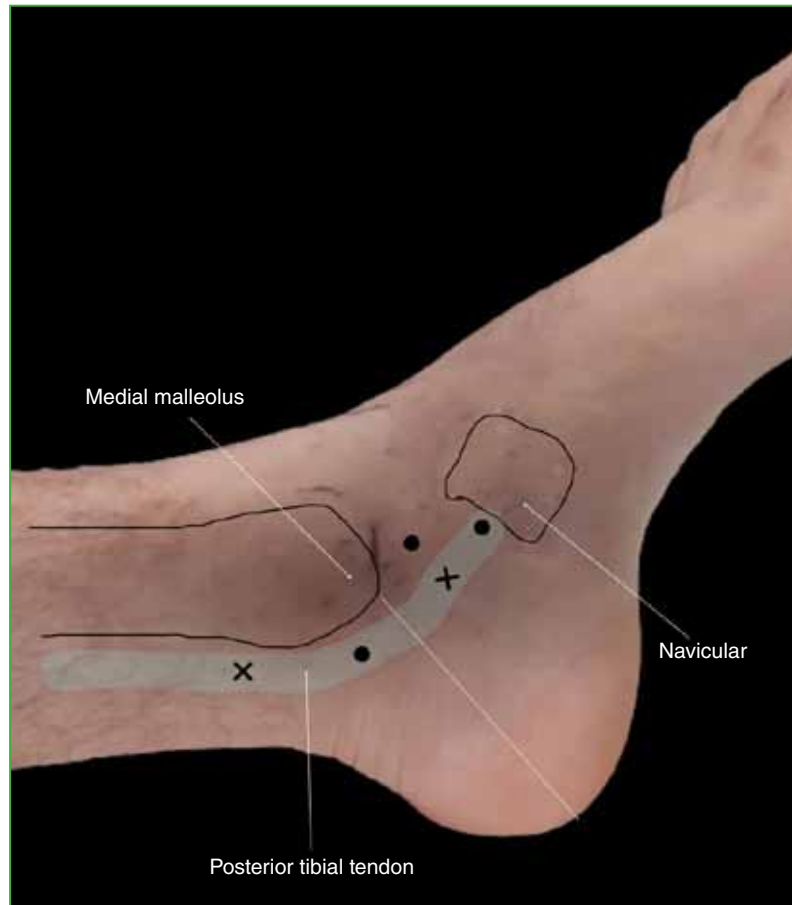
An anatomical investigation was performed on six fresh frozen cadaveric pieces; four (66.67%) were left and two (33.33%) were right. The specimens were prepared by the technical staff of the laboratory. They had been amputated at the infrapatellar level, with preservation of the proximal insertion of the PTT.

An injury was caused to the superomedial ligament of the spring ligament with a radiofrequency ablation device and endoscopic repair was performed. The portals were made as described in the surgical technique. After entering the PTT sheath, the spring ligament was identified and repaired. All cadaveric pieces were dissected to evaluate the effectiveness of the suture performed, the portals, and their relationship with the vital structures of the studied anatomical region.

### Surgical technique

The procedure is carried out with a 4 mm scope at a 30° angle, allowing a much wider field of view (a 2.7 mm scope can also be used). For the surgical technique, a Mini Scorpion suture passer clamp (Arthrex® Inc., Naples, Florida, USA) is used.

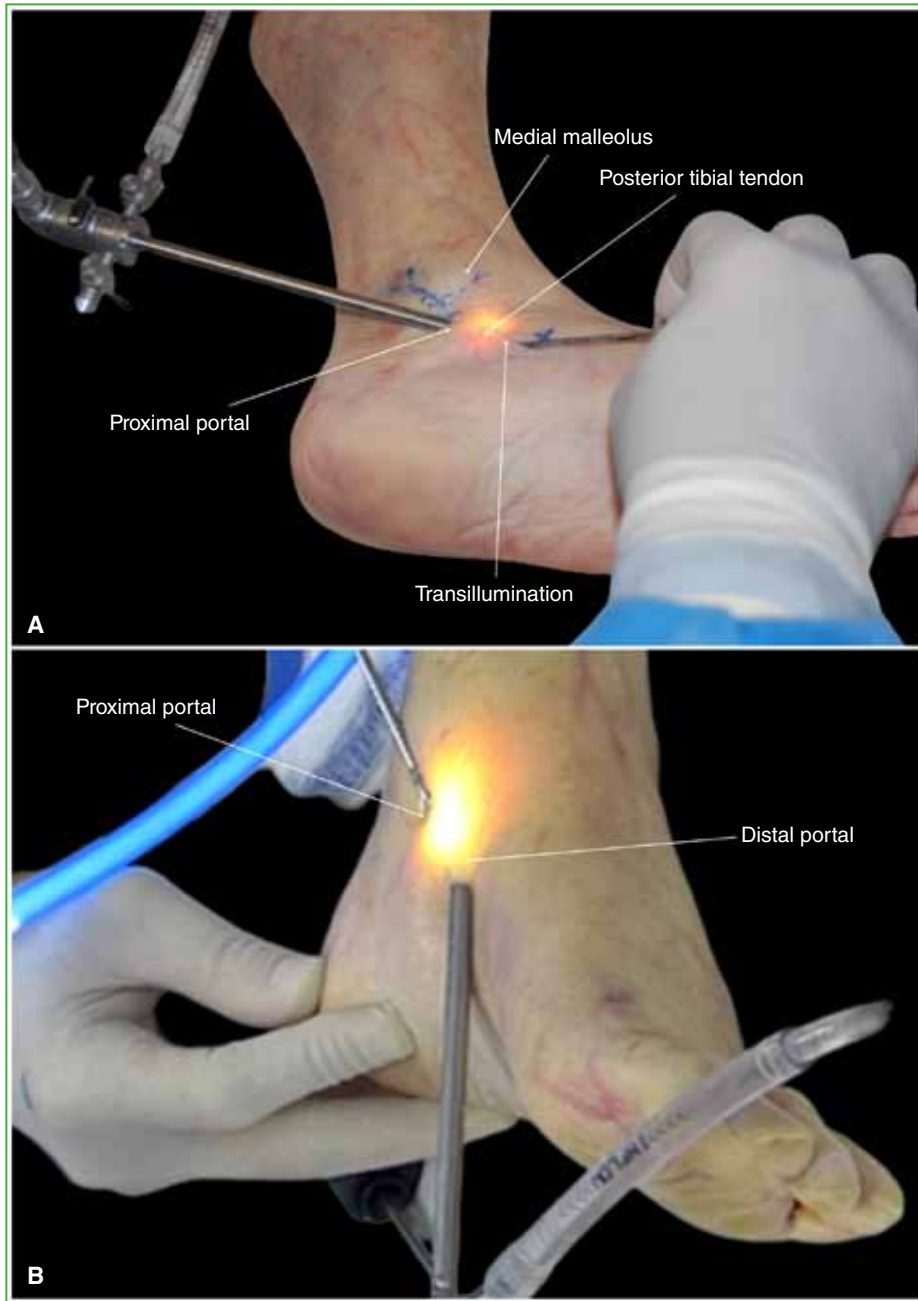
The first portal is located just behind the tip of the medial malleolus, proximal to a line drawn from the end of the inner malleolus to the central area of the heel. First, saline is injected into the PTT sheath (Figure 1). Skin is cut only with a No. 15 scalpel and a straight Halstead mosquito clamp is used to open the tendon sheath. At this point, it is important to check if we are inside the correct sheath (posterior tibial tendon), as the clamp might slip inside the sheath of the flexor digitorum longus tendon. Moving the toes is a simple maneuver to verify the correct location of the scopes.



**Figure 1.** Classic location of portals for posterior tibial tendoscopy (crosses). Modification of the classic tendoscopy portals, recommended for better visualization of the calcaneonavicular ligament or *spring ligament*. Accessory dorsal portal to the posterior tibial tendon (dots).

The second portal is placed 0.5 cm proximal to the distal insertion of the PTT by transillumination and with the help of an intramuscular needle in the endoscopic vision for a correct location (Figure 2).

If the ligament injury is difficult to repair or it is not possible to maneuver with the Mini Scorpion® clamp within the tendon sheath, a third accessory portal, immediately dorsal to the tendon path, can be placed midway between the portals already described, to facilitate repair with the suture-passer clamp (Figure 3) (Video ▶).



**Figure 2.** Location of the portals. **A.** Location of the distal portal guided by transillumination. Note the needle for endoscopic guidance. **B.** Location of the scope in the proximal portal. Note the hand position to provide a more stable grip, as described by van Dijk et al.



**Figure 3.** Location of the accessory portal. The probe entering through the portal allows the mobilization of the posterior tibial tendon or, eventually, the entry of the suture passer clamp to repair the calcaneonavicular ligament. Nylon 4-0 is used to close the portals.

## RESULTS

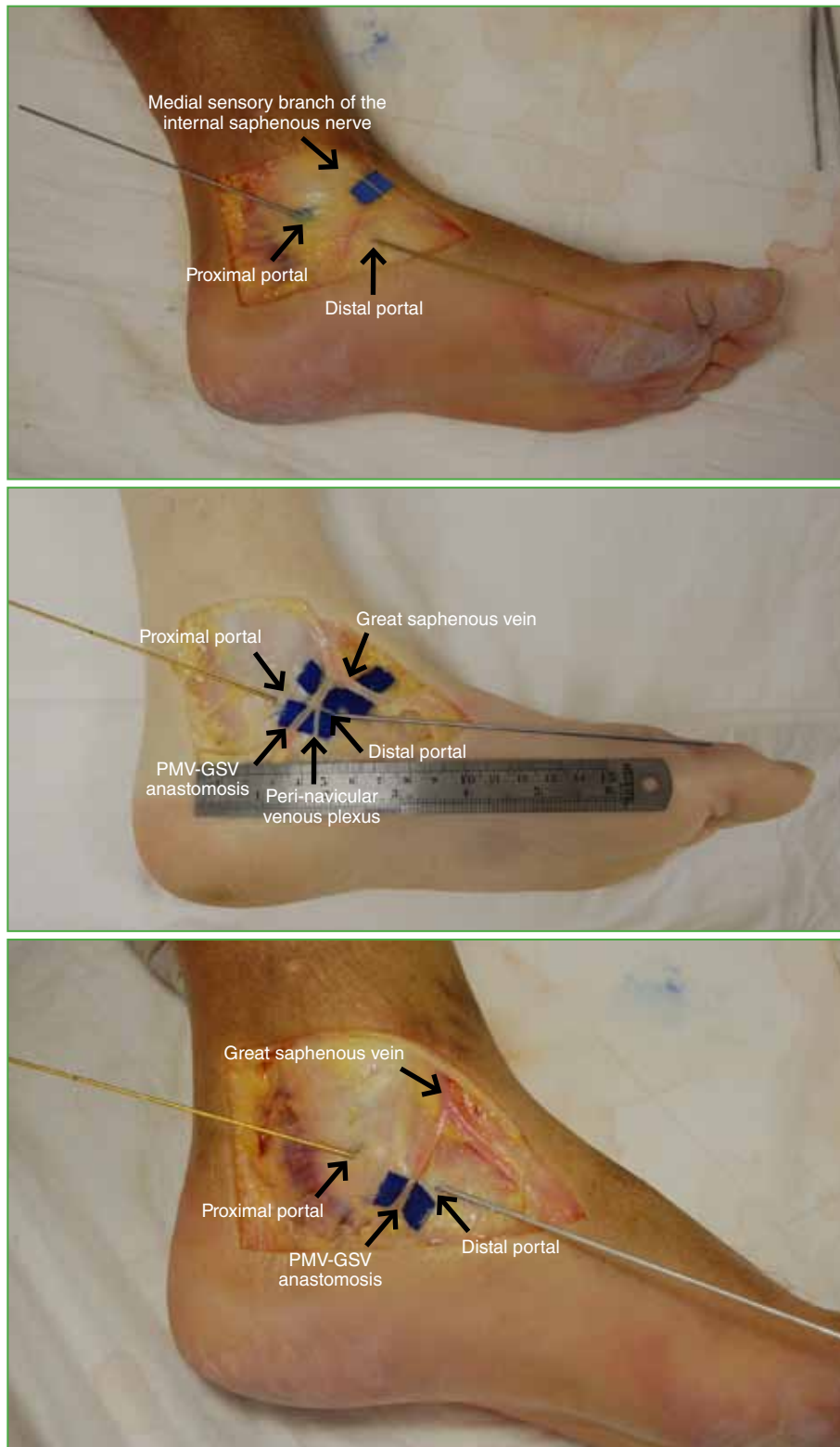
Endoscopic repair with two portals could be performed on all specimens used. Only in one, an accessory portal was used to allow better maneuverability with the suture-passer clamp in ligament repair.

In the medial region of the ankle and the hindfoot, there are usually two communicating branches of the great saphenous vein: the anastomosis between the medial plantar vein and the great saphenous vein, and a distal vascular branch that corresponds to the perinavicular venous plexus.<sup>7,8</sup> All the samples in our series had this vascular anastomosis, while 50% had a perinavicular venous plexus.

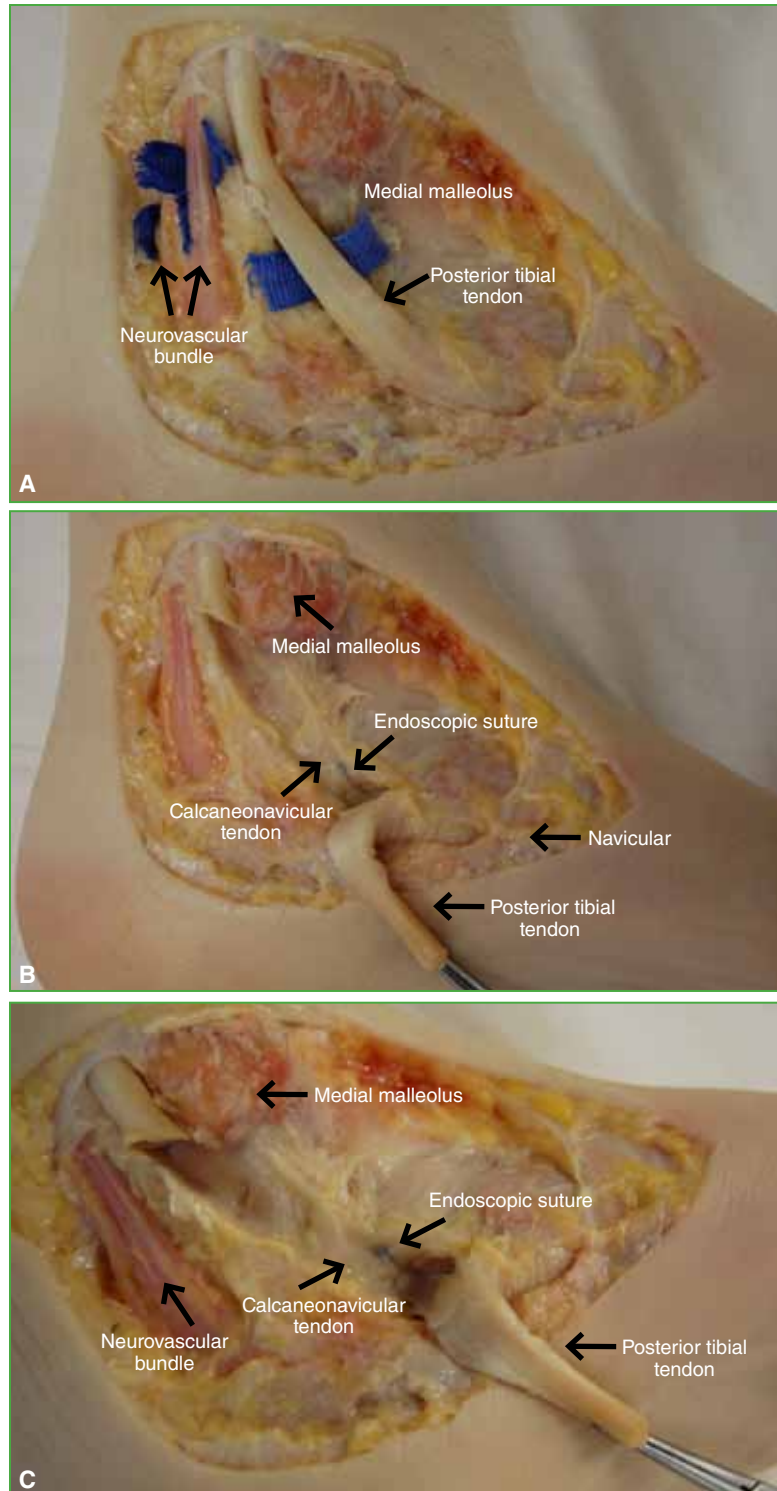
The saphenous nerve is posterior to the saphenous vein and is divided into two branches, a small one ending at the level of the ankle joint and a second sensory branch passing in front of the tibial malleolus and giving superficial endings on the medial side of the foot to the hallux.<sup>5</sup> The medial sensory branch of the internal saphenous nerve could be observed in all specimens and the average distance was >30 mm from the portals used (Figure 4A).

The average distance from the vital vascular elements to the proximal portal was 11.83 mm (range 5-20) and, to the distal portal, 9.66 mm (range 3-22) (Figure 4B and C).

In a single anatomical sample, it was necessary to use the accessory portal to improve the suturing maneuver with the suture passer clamp. In the dissection, it was observed that it was located 2 mm from the branches named above (Figure 5). The results are summarized in the Table.



**Figure 4.** Vital structures near the portals. **A.** Sensitive branch of the internal saphenous nerve. **B.** In this anatomical specimen, anastomosis of the plantar medial vein (PMV) with the great saphenous vein (GSV) can be observed, as well as part of the peri-navicular venous plexus, and the distance from the portals. **C.** PMV-GSV anastomosis, without the presence of the peri-navicular venous plexus.



**Figure 5. A.** Anatomical relationship with the posterior tibial neurovascular bundle. **B and C.** Endoscopic repair of the calcaneonavicular ligament. In these specimens, the final result of endoscopic suturing of the calcaneonavicular ligament is shown. Perpendicular to the arrow is the suture thread that closes the ligament gap and the knot proximal to it. Below, the ligament lesion line is closed by the suture

**Table.** Results of the study

Specimen	Foot	Perinavicular venous plexus	PMV-GSV anastomosis	Distance to the proximal portal (mm)	Distance to the distal portal (mm)	Accessory portal	Spring ligament repair
1	Left	Yes	Yes	5	5	No	Yes
2	Right	Yes	Yes	10	6	Yes	Yes
3	Right	No	Yes	20	15	No	Yes
4	Left	No	Yes	20	7	No	Yes
5	Left	Yes	Yes	13	3	No	Yes
6	Left	No	Yes	3	22	No	Yes

PMV = plantar medial vein; GSV= great saphenous vein

## DISCUSSION

In recent studies, it has been proposed that degenerative or traumatic injuries to the spring ligament and deltoid ligament may be precursor injuries to the complete pathology of the adult flatfoot.<sup>5,6,9</sup> With new imaging techniques and a clearer clinical presentation, these injuries can be detected and diagnosed early.

In biomechanical studies, it has been shown that spring ligament injury, cyclic foot loading, and bone factors that compromise ankle and hindfoot alignment are all causes of deformity and, over time, can lead to progressive collapsing foot deformity or acquired adult flatfoot.<sup>4</sup> Spring ligament involvement has been noted as a primary causal factor in peritalar subluxation.<sup>10,11</sup> Because of this, surgical ligament repair or reconstruction has become an important factor in treatment. On numerous occasions, it requires extensive soft tissue dissection because the ligament is a deep structure. The evaluation and endoscopic treatment of the ligament can avoid unnecessary open exploration and have the advantage of achieving better aesthetic results, with lower morbidity and postoperative pain.<sup>12,13</sup>

Wertheimer was the first to describe, in 1995, a technique to perform a PTT endoscopy on a patient; the site of the portals was 2 cm proximal to the medial malleolus and 2 cm distal to it, the classics for PTT tendoscopy.<sup>14</sup>

In their 1997 dissection study, van Dijk et al. pointed out that the tendon can be accessed through any part of its path, and described both portals 2 or 1.5 cm from the medial malleolus to proximal and distal. In their research, they used a 2.7 mm scope.<sup>15</sup>

In 2007, Lui introduced a technique of endoscopic repair of the PTT with an anterior tibial hemigraft, for grade II dysfunctions, where the distal portal is performed 1 cm from the navicular and uses a 2.7 mm scope; he also recommended the possible use of a 4.0 mm scope.<sup>12</sup>

Another report by the same author in 2016 describes a variant in the surgical technique for endoscopic repair of the spring ligament by adding a plantar medial accessory portal to the classic tendoscopy portals and a suture-passing instrument (Viper Suture Passer®, (Arthrex® Inc., Naples, Florida, USA)).<sup>16,17</sup> The author also points out the safety of the portals, especially the plantar accessory portal to the path of the PTT, and reports that the only structure at risk when using this accessory portal is the medial or internal plantar branch of the posterior tibial nerve. He also described the possibility of spring ligament repair through arthroscopy of the talonavicular joint.<sup>16</sup>

In our study, with the portals made in the way we describe them in our surgical technique, the possibility of causing the nerve injuries already mentioned is minimized, because we do not use any plantar portal for access to the spring ligament or PTT, but a dorsal accessory portal located midway between the other two described.

We recommend this procedure for experienced surgeons, as it has a medium learning curve and requires specific knowledge of foot anatomy and special instrumentation, in addition to the ability to resolve any complications that arise during the procedure.

The limitations of this study are due to the use of cadaveric specimens and the number of pieces used. For future lines of research, we propose to carry out clinical, prospective, randomized and comparative studies with more specimens that allow better statistical analysis and a final evaluation of the technical results.

## CONCLUSIONS

Endoscopy is an effective technique for the diagnosis and treatment of spring ligament superomedial ligament lesions. According to the results of our anatomical dissection, we can conclude that the portals used are safe for the surgical technique described and also for the endoscopic repair of the spring ligament. It was reproducible in all specimens, it was possible to close the gap produced, artificially, in all cases, without any injury to the regional vital structures, which remained at a sufficiently safe distance from the portals used for the procedure.

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# Scores VI

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## ABSTRACT

The Editorial Committee wants to provide its readers with an update on the commonly used scales. The use of tables and scales is a widespread practice in Orthopedics and Traumatology. The measurement and quantification of clinical, functional, and radiographic aspects has become an essential tool for decision-making in different aspects of healthcare activity. We carry out a review of the most used scales, defining their use and including original and updated literature.

**Keywords:** Scales; scores; tables; update

**Level of Evidence:** V

## Puntajes VI

## RESUMEN

El Comité Editorial quiere brindar a sus lectores una actualización de las escalas de uso corriente. El empleo de tablas y escalas es una práctica muy extendida en la Ortopedia y Traumatología. La medición y la cuantificación de los aspectos clínicos, funcionales y radiográficos se convirtieron en una herramienta imprescindible para la toma de decisiones en diferentes aspectos de la actividad asistencial. Llevamos a cabo una revisión de las escalas más utilizadas, definiendo su uso e incluyendo bibliografía original y actualizada.

**Palabras clave:** Escalas; puntajes; tablas; actualización

**Nivel de Evidencia:** V

## INTRODUCTION

The Editorial Committee wants to provide its readers with an update on the most commonly used scales. The use of tables and scales is a widespread practice in Orthopedics and Traumatology. The measurement and quantification of clinical, functional, and radiographic aspects have become essential tools for decision-making in different aspects of healthcare activity.

We carried out a review of the most used scales, defining their use and including original and updated literature. In this opportunity, we dealt with the section of ankle and foot scores.

## AOFAS Foot and Ankle Score

It was developed by Kitaoka in 1994 and covers four different regions: ankle and hindfoot, midfoot, metatarsophalangeal and interphalangeal joints of the hallux, metatarsophalangeal and interphalangeal joints of the other toes. These four anatomical regions have their own version in the American Orthopaedic Foot and Ankle Society (AOFAS) study. Each is designed to be used independently. However, each measure is composed of nine questions and covers three categories: pain (40 points), function (50 points) and alignment (10 points). These categories are added to form a total of 100 points.

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## AOFAS Ankle-Hindfoot Scale

### Pain (40 points)

- None (40)
- Mild, occasional (30)
- Moderate, daily (20)
- Severe, almost always present (0)

### Function (50 points)

#### Activity limitations, support requirements

- No limitations, no support (10)
- No limitation of daily activities, limitations of recreational activities, no support (7)
- Limited daily and recreational activities, cane (4)
- Severe limitation of daily and recreational activities, walker, crutches, wheelchair, brace (0)

#### Maximum walking distance, blocks (approximately 100 m).

- Greater than 6 (5)
- Between 4 and 6 (4)
- Between 1 and 3 (2)
- Less than 1 (0)

#### Walking surfaces

- No difficulty on any surface (5)
- Some difficulty on uneven terrain, stairs, inclines, ladders (3)
- Great difficulty on uneven terrain, stairs, inclines, ladders (0)

#### Gait abnormality (limp)

- None, slight (8)
- Obvious (4)
- Marked (0)

#### Sagittal motion (flexion plus extension)

- Normal or mild restriction ( $>30^\circ$ ) (8)
- Moderate restriction ( $15-29^\circ$ ) (4)
- Severe restriction ( $<15^\circ$ ) (0)

#### Hindfoot motion (inversion plus eversion)

- Normal or mild restriction (75-100% normal) (6)
- Moderate restriction (25-74% normal) (3)
- Severe restriction ( $<25\%$  of normal) (0)

#### Ankle-hindfoot stability (anteroposterior, varus-valgus)

- Stable (8)
- Clearly unstable (0)

#### Alignment (10 points)

- Good, plantigrade foot, well-aligned midfoot (10)
- Fair, plantigrade foot, some degree of malalignment, no symptoms (5)
- Poor, nonplantigrade foot, severe malalignment, symptoms (0)

### TOTAL (100)

*AOFAS midfoot scale***Pain (40 points)**

- None (40)
- Mild, occasional (30)
- Moderate, daily (20)
- Severe, almost always present (0)

**Function (45 points)****Activity limitations, support requirements**

- No limitations, no support (10)
- No limitation for daily activities, limitation of recreational activities, no support (7)
- Limited daily and recreational activities, cane (4)
- Severe limitation of daily and recreational activities, walker, crutches, wheelchair (0)

**Footwear requirements**

- Fashionable, conventional shoes, no insert required (5)
- Comfort footwear, shoe insert (3)
- Modified shoe or brace (0)

**Maximum walking distance, blocks (approximately 100 m)**

- Greater than 6 (10)
- Between 4 and 6 (7)
- Between 1 and 3 (4)
- Less than 1 (0)

**Walking surfaces**

- No difficulty on any surface (10)
- Some difficulty on uneven terrain, stairs, inclines, ladders (5)
- Great difficulty on uneven terrain, stairs, inclines, ladders (0)

**Gait abnormality (limp)**

- None, slight (10)
- Moderate, evident (5)
- Marked (0)

**Alignment (15 points)**

- Good, plantigrade foot, well-aligned midfoot (15)
- Fair, plantigrade foot, some degree of malalignment, no symptoms (8)
- Poor, nonplantigrade foot, severe malalignment, symptoms (0)

**TOTAL (100)**

*Metatarsophalangeal and interphalangeal AOFAS scale*

<b>Pain (40 points)</b>	
• None	(40)
• Mild, occasional	(30)
• Moderate, daily	(20)
• Severe, almost always present	(0)
<b>Function (45 points)</b>	
<b>Activity limitations, support requirements</b>	
• No limitations, no support	(10)
• No limitation for daily activities, limitation of recreational activities, no support	(7)
• Limited daily and recreational activities, cane	(4)
• Severe limitation of daily and recreational activities, walker, crutches, wheelchair	(0)
<b>Footwear requirements</b>	
• Fashionable, conventional, no insert required	(10)
• Comfort footwear with shoe insert	(5)
• Modified shoe or brace	(0)
<b>Metatarsophalangeal joint motion (dorsiflexion plus plantarflexion)</b>	
• Normal or mild restriction (>75°)	(10)
• Moderate restriction (30-75°)	(5)
• Severe restriction (<30°)	(0)
<b>Interphalangeal joint motion (plantarflexion)</b>	
• No restriction	(5)
• Severe restriction (<10°)	(0)
<b>Metatarsophalangeal-interphalangeal stability (all directions)</b>	
• Stable (5)	
• Unstable (0)	
<b>Calluses related to metatarsophalangeal-interphalangeal hallux</b>	
• No or asymptomatic callus or corn/clavus	(5)
• Symptomatic callus or corn/clavus	(0)
<b>Alignment (15 points)</b>	
• Good, plantigrade foot, well-aligned midfoot	(15)
• Fair, plantigrade foot, some degree of malalignment, no symptoms	(8)
• Poor, nonplantigrade foot, severe malalignment, symptoms	(0)
<b>TOTAL (100)</b>	

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